World Sustainability Series

Walter Leal Filho · Amanda Lange Salvia · Rudi W. Pretorius · Luciana Londero Brandli · Evangelos Manolas · Fatima Alves · Ulisses Azeiteiro · Judy Rogers · Chris Shiel · Arminda Do Paco *Editors*

Universities as Living Labs for Sustainable Development

Supporting the Implementation of the Sustainable Development Goals

Springer

World Sustainability Series

Series Editor

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Due to its scope and nature, sustainable development is a matter which is very interdisciplinary, and draws from knowledge and inputs from the social sciences and environmental sciences on the one hand, but also from physical sciences and arts on the other. As such, there is a perceived need to foster integrative approaches, whereby the combination of inputs from various fields may contribute to a better understanding of what sustainability is, and means to people. But despite the need for and the relevance of integrative approaches towards sustainable development, there is a paucity of literature which address matters related to sustainability in an integrated way.

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Preface

A living labs approach provides good opportunities to improve the environmental sustainability of universities, combining the expertise of staff and students, and encourages the application of knowledge to a real-world context. But despite its relevance and applicability, the use of a living labs approach is not as widely used as it can- or should-be.

This book addresses the need for academic materials related to living labs in a sustainable development context. It contains a set of papers presented at the "4th World Symposium on Sustainable Development at Universities" (WSSD-U-2018), which was held at the Universiti Sains Malaysia (USM) in Malaysia, organised by Manchester Metropolitan University (UK), the Research and Transfer Centre "Sustainable Development and Climate Change Management" of the Hamburg University of Applied Sciences (Germany), and the World Sustainable Development Research and Transfer Centre, in cooperation with the Inter-University Sustainable Development Research Programme (IUSDRP) and the United Nations University initiative "Regional Centres of Expertise on Education for Sustainable Development" (RCE).

The "4th World Symposium on Sustainable Development at Universities" (WSSD-U-2018) focused on "Universities as Living Labs for Sustainable Development: Supporting the Implementation of the Sustainable Development Goals" and provided a contribution to the further development to the debate on the use of a living labs approach as a means to foster the cause of sustainable development at higher education institutions.

This book is structured around three main parts as follows:

Part I: Campus as Living Labs for the SDGs
Part II: Education for Sustainable Development
Part III: Sustainability Processes and Practices

This publication documents practical experiences on education, research and extension (the so-called 3rd Mission, whereby universities outreach to local communities, industry and other groups) and makes them available to a wide audience.

It outlines many initiatives performed at universities to promote environmental sustainability and many interesting case studies from around the world.

We thank the authors for their efforts in elaborating the manuscripts and the reviewers for the many useful comments provided. We hope this book will inspire further initiatives in this rapidly growing field.

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Part I
Campus as Living Labs for the SDGs

Living Labs for Sustainable Development: The Role of the European School of Sustainability Sciences and Research

Walter Leal Filho

Abstract This first chapter provides an overview of the concept of living labs for sustainable development and introduces the European School of Sustainability Science and Research as an example of a European wide integrative effort to foster sustainability using a living labs approach.

Keywords Living labs · Sustainable development · Innovation · Ideas · Europe

1 Introduction

The current levels of depletion of natural resources suggests that we urgently need to change the way we teach and do research on environmental issues as a whole, and the ways we tackle matters related to sustainable development in particular. We need to move away from linear economic models, and towards circular ones, where renewable resources are used and social engagement is catalysed.

The "Agenda 2030" agreed by the UN in 2015 and the Sustainable Development Goals (SDGs) in particular, are acting as drivers to more collaborative action in the field of sustainable development, by means of the "quadruple helix model", i.e. a model which entails linkages between government, academia, society and business. These actors may join efforts in seeking local solutions to global problems, hence mobilising a variety of sectors of society, some of which are not often engaged on sustainability efforts.

The higher education sector has been responding to the challenges sustainability poses to it, in a variety of ways. It may be by means of participatory approaches (Disterheft et al. 2014), or by executing campus assessments (Arroyo 2015), among many other means.

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Higher education institutions have also been very diligent in reacting to the calls to help to implement the SDGs (Leal Filho et al. 2018). Universities need to attend the demand from students for new, learner-centred approaches to teaching, integrating SD competences and fostering them in an interdisciplinary way, deploying for this purpose innovative learning methodologies, teaching concepts and didactic tools.

Across the world, many initiatives have been started, and many are in the planning phases, to tackle the many changes related to the implementation of sustainable development. There are also many tools being developed and deployed, to this purpose.

One of them is the "**living labs**" approach, which provides a sound basis for the holistic tackling of sustainable development themes, with a variety of focus and areas. Some of them are:

i. Waste
ii. Water
iii. Energy
iv. Ecosystems protection
v. Social issues, including social responsibility

among many others.

According to Liedtke et al. (2012), a living lab is a "combined lab-/household system, analysing existing product-service-systems as well as technical and socioeconomic influences focused on the social needs of people, aiming at the development of integrated technical and social innovations".

As an example of what can be done, Masseck (2017) demonstrated the platform "Living Lab LOW3", which allows the creation of synergies between actors, programs and projects with an example from the building sector. As part of "Living Lab LOW3", stakeholders have the opportunity to participate in a community of users beyond established academic structures.

Leal Filho (2015) explained the usefulness of the living labs approach as part of transformative efforts.

But in order to succeed, a living labs approach need to consider not only the need for innovative ways of teaching, but also more research and technology transfer based on a strong interaction between the universities and their local and regional communities.

Also, living labs need to encourage organisations to move forward, from being based on individual activities towards a whole-institution approach as shown in Fig. 1.

One of the contributions the Living Labs approach can provide, is the support of interactions between the academic sector and other parts of society, a goal achieved by means of multi-stakeholder engagement in new open and experimentative processes carried out in real world contexts. In this context, local stakeholders may be involved in a variety of ways, for instance:

(a) by means of projects
(b) by means of sharing economy initiatives
(c) by means of tools to foster their participation and engagement

Fig. 1 Evolution of a living labs approach

(d) by means of research meant to drive and support sustainable habits and behaviours
(e) by means of demonstration activities which put principles into practice.

Living Labs should not only act as sources of information, but they should also catalyse changes in the sense of societal transformation, and the fostering of more sustainable life styles and practices. As mentioned by Evans et al. (2015), they may be used as co-production and as platforms for sustainability science.

They should also provide a fertile ground to conceive, prototype and test sustainable living solutions, also facilitating cooperation and collaboration across various sectors, hence catalysing the integration of sustainability and innovation.

Table 1 Illustrates some of the measures universities may deploy, with a view to maximise their potentials as living labs.

By means of due consideration to these elements, a sound basis for the integration of concurrent research and innovation processes.

2 The Benefits of Living Labs

Figure 2 describes the benefits from a living labs approach. It can be seen that there are many, and that their nature suggest a living lab approach may be advantageous to universities in many ways.

All in all, the many advantages suggest that the time and resources to be spent in developing a living labs approach are worthy the investment.

Table 1 Measures to maximise universities' potentials as living labs

Procedure	Means of implementation
Work in an integrated manner	Try to engage colleagues across department and disciplines
Engage local stakeholders	Go beyond the university and engage external actors, many are happy to engage
Pursue partnerships	Seek synergies with organisations pursuing similar goals
Document experiences	Staff should take the time to write down their experiences and publish them
Make an effort to meet peers	Whenever possible, staff should try to attend gatherings to exchange idea and get nee information
Be visible	Show and promote what you do
Foster talent	Engage students at different levels: B.Sc., M.Sc., Ph.D.

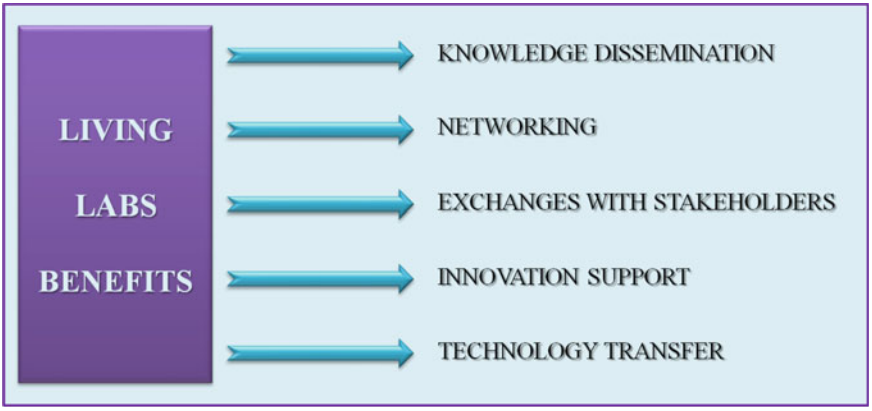

Fig. 2 Benefits from a living labs approach

3 ESSSR as a Living Lab

There is at present in Europe no single organization or setting, which coordinates efforts in the field of sustainability science teaching and research on the continent, in an integrated way. Yet, much could be gained if the extensive body of knowledge, expertise and resources which European universities currently have available, could be consolidated, with a view to strengthening their profiles, activities, and scientific outputs. It is on the basis of the need to address this gap, that the "European School of Sustainability Science and Research" (ESSSR) was created.

ESSSR is an inter-university consortium composed by members which share an interest on sustainability science and on matters related to sustainable development. Once operating, it will be a key organization, filling in a gap in respect of the coordination of sustainability science teaching and research at European universities seen today.

The mission of ESSSR is:

> To provide a framework upon which teaching and research within the remit of sustainability science may be further developed at European universities, by means of joint, digitally-oriented teaching programmes, research projects, Ph.D. training and quality scientific publications to be published in high calibre journals.

ESSSR was brought to life based on the perceived need to explore new ideas, develop new approaches and new methods in the field of sustainability science, to meet current and future needs, and which can also help to achieve the many goals listed in the document "Transforming our world: the 2030 Agenda for Sustainable Development".

ESSSR works as a living lab, in the following ways:

I. it provides a platform for universities to discuss the contribution of Sustainability Science and Research towards the implementation of the SDGs;
II. it mobilises universities working with sustainable development, to gather, deliberate and implement joint initiatives, especially online courses, research projects and specialist publications, which show how Sustainability Science and Research can help to achieve the SDGs;
III. it contributes to the education of next generation of sustainability scientists, by means of on-line courses and joint Ph.D. programmes on sustainability science.

In addition, ESSSR links European sustainability researchers with their counterparts in other parts of the world (north-south and south-south cooperation on sustainable development). ESSSR also strengthens interdisciplinary and pioneering research on sustainability issues, by also paving the way for post-doctoral positions and fellowships across its members.

ESSSR undertakes activities focusing on four main areas, in cooperation with its partners:

Area 1- Courses on sustainability science, especially online ones, hence furthering the digitalisation of teaching and learning
Area 2- Research projects on sustainability science
Area 3- Research publications on sustainability science
Area 4- Joint training of Ph.D. students on sustainability science, as well as post-doctoral positions and fellowships.

These four key areas also address the need for integrated approaches towards sustainable development, and hence contribute to the implementation of the SDGs. The themes the ESSSR are as follows:

Theme 1: Political, social and economic dimensions of sustainable development
Theme 2: Environmental and technological dimensions of sustainable development
Theme 3: Holistic approaches to sustainable development
Theme 4: Stakeholders' engagement in sustainable development
Theme 5: Education for sustainable development.

ESSSR is a worthy investment to its members for a number of reasons:

(a) members can join efforts to perform works on sustainability in an integrated way and do not work alone.
(b) ESSSR supports the research strategies of member universities in four central areas:
    (i) internationalisation by being part of a strong European consortium, collaborating with many member universities;
    (ii) increase in the income from research projects by having qualitatively and quantitatively more projects on sustainability issues;
    (iii) training of more Ph.D. students, by means of joint supervisions of more Ph.D. theses and post-doctoral fellows, engaging interested professors from different Faculties;
    (iv) fosters technology transfer by bringing the results of scientific projects to use, supporting societal changes
(c) ESSSR equally fosters teaching (by digital means) and research, with contents which may be beneficial to many university students
(d) It enhances the image of the member universities as internationally-oriented research organisations, and markets them internationally as key players on the subject
(e) The new projects generated, automatically lead to additional income and overheads
(f) The investment needed is modest, with an office and contact person to serve as the link and coordinate the inputs of each member university.

Finally, being part of an institution such as ESSSR assists members' efforts to access mainstream funding from research, being part of many other projects, hence increasing their presence in the international research arena.

4 Conclusions

The Living Lab approach provides opportunities to both students and research staff to engage more on social, economic and environmental sustainability, both within a university's setting and outside it.

In order to yield the expected benefits, living labs should draw on the available expertise of staff and the inherent talent of students, as well as take into account inputs from their local communities, to foster the application of knowledge to current and concrete situations and contexts.

The ESSSR is an attempt to promote a living labs approach and to work on an integrated manner, to help to improve an institution's environmental sustainability, to train staff, students, foster publications and the dissemination of good practice. By doing so, it may integrates principles into practices, and provide a concrete contribution towards a more sustainable living.

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Aligning Campus Strategy with the SDGs: An Institutional Case Study

Chris Shiel, Neil Smith and Elena Cantarello

Abstract Evidence suggests that while many universities promote their green credentials, fully embedding sustainability across the university (campus, curriculum and community) and securing the full engagement of academic staff, is not without challenge. This paper argues that the Sustainable Development Goals may provide an opportunity to revitalise institutional efforts in relation to education for sustainable development. A case study is presented of an institution that is well-regarded for its green credentials yet continues to struggle to ensure that education for sustainable development permeates the curriculum, despite institutional strategy and policy drivers. The potential of the Sustainable Development Goals to catalyse further engagement within the institution is explored; examples are provided of how they are being used both within the curriculum, and also influencing strategy change. The conclusion suggests that while there is potential in a change of focus, substantial efforts are required to reinforce the responsibilities of higher education in relation to the goals. This paper will be useful to anyone interested in embedding sustainable development within universities and developing a strategy to address the global goals.

Keywords Sustainable development · SDGs · Higher education · Case studies

1 Introduction

In September 2015, world leaders made a commitment to the Sustainable Development Goals (SDGs) formulating 17 goals, aimed at achieving an end to extreme poverty, combatting inequality and injustice and tackling climate change, by 2030.

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It is incumbent on each signatory to bring the goals to life; nothing will be achieved without action on multiple fronts. While governments need to develop national strategies and approaches for realising the goals, all organisations in society have a role to play in contributing to their achievement. Higher education institutions (HEIs), in particular, should be taking a leading role, through research (Leal Filho et al. 2017a); they should also be educating students in relation to the goals and, inspiring engagement within their communities. Just as the role of HEIs has been made quite clear in relation to sustainable development, with a need for integrative approaches (Leal Filho et al. 2015), the role of universities in relation to the SDGs is obvious, albeit not explicit. What is less clear however, is whether universities will fully appreciate their responsibility for the SDGs. History shows that their response to calls to engage with sustainable development was not only notably slow (Tilbury 2013), but has rarely been holistic, or very strategic (Leal Filho et al. 2015). Thus, is it likely that they will respond to the SDGs with greater speed or effectiveness? Will it be the case that many universities endorse the SDGs publically but beyond that, will not regard them as a central agenda for strategic planning and action? Signing up to accords and making declarations is common place within the sector but will education strategies be transformed as consequence? Past performance does not allow for optimism. Ensuring that higher education addresses the SDGs may involve the same challenges that implementing sustainable development has faced, with similarly slow responses and partial outcomes. On the other hand, a more optimistic view, would be that the SDGs serve to inspire engagement in ways that sustainable development might not have previously, thus, some institutions will recognise their potential to catalyse change and to reinvigorate sustainable development initiatives. If a few universities take this approach and lead by example, then others will follow.

This paper offers a case study of how one institution has seen the SDGs as a catalyst, offering insights into how the SDG framework might serve as a vehicle to step-up engagement with education for sustainable development, and to take institutional strategy further.

2 Universities, Sustainable Development and the SDGs

The critical role of universities in relation to sustainable development has been consistently articulated over recent decades (see for example, 'The Sustainable University', Sterling et al. 2013). Sustainable development (in higher education) has become a significant field of research (Barth and Rieckmann 2013), to the extent that examples of what constitutes effective engagement and the many hurdles to progress, are now well documented.

As far as universities' practical engagement with sustainable development, considerable progress has been achieved in a sector that was described as notoriously resistant to change (Wals and Blewitt 2010) and where, for many years, engagement with sustainable development was deplored as both slow and inadequate (Tilbury 2013). In 2018, most universities now address environmental sustainability and/or sustainable development in some form; most will address campus sustainability and many highlight their green credentials on their institutional websites. However, while it is widely recognised that sustainable development needs to be addressed in research, campus, education and community, fewer universities have actually found ways to embed education for sustainable development across the entire curriculum (Shiel and Paço 2012), very few will evidence integrative or holistic approaches to sustainability (Leal Filho et al. 2015). Only some institutions meet the criteria for the title 'The Sustainable University' (Sterling et al. 2013). Across the world, and particularly in the UK, it is quite evident that while many universities have exemplified 'campus-greening', focused on environmental management, and are very good at promoting their green credentials, integrative approaches to sustainable development are hard to achieve and less common (Leal Filho et al. 2015).

This paper is set in the context that there is still much more to be achieved (Amaral et al. 2015; Brennan et al. 2015) if higher education is to make a full contribution to sustainable development. As the UK report on sustainability in education shows (National Union of Students (NUS) et al. 2017), leaders recognise that sustainability is a priority but are still failing to deliver. The biggest barriers identified in the report are: finances, lack of senior management commitment and strategic direction and lack of staff resources. In summary, progress to date has been slow, there is further to go and the SDGs may be a way to accelerate wider engagement.

3 The Goals and Higher Education

The SDGs represent an expanded follow-on, from the eight Millennium Development Goals (MDGs) which sought to "end poverty in all its forms" (United Nations 2015, p. 2). While some good progress was made towards the MDGs (which expired in 2015) they were never fully achieved; they had very little impact (beyond a research agenda and taught as a topic on a limited number of programmes) on the day-to day activity of higher education. Sachs (2012) provides a useful summary of development, from the MDGs to the SDGs, the latter seek a shared focus on economic, environmental, and social goals as a hallmark of sustainable development. As the SDGs emerged following rigorous and extensive consultation, they constitute a broad consensus on which the world can build through cooperation between stakeholders. Although they are not legally binding, they are likely to be a major influencer on governments and organisations over the next fifteen years.

The United Nations (2015, p. 14) articulates the 17 goals:

- Goal 1. End poverty in all its forms everywhere
- Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
- Goal 3. Ensure healthy lives and promote well-being for all at all ages
- Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

- Goal 5. Achieve gender equality and empower all women and girls
- Goal 6. Ensure availability and sustainable management of water and sanitation for all
- Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all
- Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
- Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
- Goal 10. Reduce inequality within and among countries
- Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable
- Goal 12. Ensure sustainable consumption and production patterns
- Goal 13. Take urgent action to combat climate change and its impacts*
- Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
- Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
- Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
- Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.

Of the seventeen SDGs, only Goal 4 explicitly references education however Mader and Rammel (2015) suggest that universities have a much wider transformative role to play to achieve sustainable development. In their opinion, the most pertinent SDGs for education are Goals 4, 9, 12, 16 and 17. Although they highlight specifically just five goals, what is of overarching importance is that all students need to understand the implications of the entirety of the framework; all students need to develop the knowledge and skills required to live sustainably, within environmental limits. Further, meeting the SDGs will require universities to provide appropriately skilled graduates (Association of Commonwealth Universities 2015) and this will require rethinking the curriculum. Dramatically more globally relevant curricula are needed in all countries if students are to meet employability requirements and to address the social, environmental cultural, economic and health challenges that the world faces (Hall and Tandon 2013).

An inspiring publication by the Sustainable Development Solutions Network in the Pacific Rim (SDSN Australia/Pacific 2017) exemplifies what needs to happen in regard to the SDGs. The paper reinforces that universities (as knowledge creators) must play a vital role in developing those who will be the current and future implementers of the SDGs; "Addressing the challenges of the SDGs will require new knowledge, new ways of doing things, hard choices between competing options, and in some cases profound transformations" (p. 8). Further, the paper suggests that an extensive contribution involves universities embodying the SDGs through organisational governance, operations and culture, as well as using their leadership role to influence partners and stakeholders in the community. The paper (p. 9) also sets out why universities need the SDGs: to demonstrate impact; capture demand for SDG related education; to build new partnerships and to access new funding streams.

Their guide is to be applauded and suggests that what is required for the SDGs is a strategic and integrative approach to sustainability, as has been argued previously for sustainable development (e.g. Leal Filho et al. 2015; Sterling et al. 2013)—through research, across the curriculum and in the extra-curricular sphere, and through working in the community to educate and encourage capacity building.

There are currently only a few early adopters of such an approach. One of the partners in the Pacific Rim collaboration, Victoria University of Wellington, New Zealand for example, has already mapped their current curriculum against the SDGs with the aim to track their own contributions towards the global goals and improve their offerings (Wilks and Van den Belt 2017). Similarly in the UK, the University of the West of England (UWE) is leading the way in taking a strategic approach to the SDGs and undertaking curriculum mapping to establish a benchmark for progress (Gough and Longhurst 2018), as is Nottingham Trent University (Willats et al. 2018) however, these examples are uncommon.

The 2017 Green Gown Awards UK and Ireland, a scheme delivered by the Environmental Association for Universities and Colleges (EAUC) that recognises exceptional sustainability initiatives undertaken by university and colleagues, tasked applicants with mapping the SDGs that their projects were delivering against. Canterbury Christ Church University emerged as another example of how a strategic approach to sustainability is transforming their University, both operationally and academically, and The London School of Economics and Political Science stated that sustainability was a fundamental strand running through teaching, research, operations and public engagement (EAUC 2017). However, not even at this high level of awards, was it possible to see that a strategic and integrative approach to the SDGs is commonplace.

In the UK, 75% of student respondents in the National Union of Students (NUS) et al. (2017) annual sector survey, reported that their institution had progressed action linked to the United Nation's SDGs initiative, seeing the SDGs as the biggest motivator of the initiatives listed. However, institutional innovators are in the minority and, there are few examples of how institutions are implementing their approaches. Further, there is no evidence yet of the impact or success of approaches. More examples are needed to share practice and particularly to extend conversations about aligning strategy with the SDGs in a higher education setting in order to build momentum for change.

4 Method

This paper adopts a case study approach (Yin 2014), and represents an empirical inquiry into sustainable development progress within a particular setting, the case study institution. Two sources of information have informed the case study: literature related to higher education, sustainable development and the SDGs; and reflection and analysis on the part of the authors, who are members of the case study university's Sustainability Strategy Group (SSG) but also champions of change. A single site case study obviously has limitations but learning from such cases is important to inform processes of systemic transformation across higher education (Sharp 2002); therein, rests the value of this paper, case studies are useful in that they demonstrate to others possibilities and challenges. They are particularly pertinent in the early stages of developments such as engaging with the SDGs within an HE setting, where examples of practice may inspire others to follow similar paths.

5 The Case Study Context: Sustainable Development at BU

Bournemouth University (BU) has consistently aimed for an integrative approach to sustainability and was one of the first institutions that sought to explore a holistic approach, the challenges of which have been documented (see Shiel and Williams 2014; Shiel and Smith 2017).

The institution (BU) is a medium-sized UK university, inaugurated in 1992, with around 19,000 students, 740 full-time equivalent academic staff and 846 professional and support staff. Environmental issues became a focus of attention at the end of the nineties with a concern for saving resources, particularly utilities. Engagement with the broader concept of sustainable development became a more strategic concern in 2005, when a strategy was developed for the whole institution; from 2006, strategy embraced both global citizenship and sustainability (Shiel 2007) with education for sustainable development becoming a curriculum requirement. The importance of a holistic approach and integrative ways of working on over-lapping agendas (Shiel et al. 2005) was established at the outset but has never been fully achieved or easy to reinforce (Shiel 2011). However the driver has been to implement an approach not dissimilar to the "4C" model (curriculum, campus, community and culture) at Plymouth University (Jones et al. 2010, p. 7). The strategic vision for the university up to 2018, has made a clear commitment to "a holistic approach" to sustainable development, with the aim of "inspiring our students, graduates and staff to enrich the world", and the assurance that: "we will ensure our environmental credentials are held in high esteem" (Bournemouth University 2012). Substantial progress has been made over the course of the strategy and BU is perceived as one of the greener universities in the UK, with a 'first-class' award, consistently maintained in the UK Green League (People and Planet 2017). Campus sustainability is such that the estates at BU provide a very good 'Living Lab' environment where students learn from and contribute to campus greening approaches.

In 2016, a number of actions were pursued to achieve a "step change" in progress, and to reinforce a holistic approach:

- Achieving the highest credential to exemplify best practice in the environmental management of the University (i.e. EcoCampus Platinum and ISO14001 certification)
- Reinvigorating the education agenda
- Developing the culture and building capacity by working in the extra-curricular sphere—initiating Green Impact teams across the university (Shiel and Smith 2017).

The actions resulted in partial success.

EcoCampus Platinum (EcoCampus 2018) and ISO14001:2004 (International Organization for Standardization (ISO) 2015) certification was achieved in 2016 and BU became, at that time, one of only 15 universities with this dual certification. EcoCampus was designed by the higher education sector to help universities implement environmental management systems (EMS). An EMS is a risk management tool to minimise the impact on the environment whilst also promoting positive impacts, such as Education for Sustainable Development (ESD). BU's EMS currently provides a structured approach, supported by senior management, to continual improvement with its ESD programme.

Reinvigorating the education for sustainable development (ESD) agenda involved working with the Centre of Excellence in Learning (CEL) and gaining approval of a sustainability focus on the Post Graduate Certificate in Education (PGCert), which is compulsory for new staff. In 2017, this took the limited form of a one-off presentation to staff on the PGCert. The presentation created some interest but was perceived as a bolt-on, with limited impact on wider curriculum change. Similarly, a competition to surface good ESD teaching practise (again in collaboration with CEL) made public a few excellent examples, but mainly only gained the participation of already engaged academics, rather than serving to inspire the wider body of staff.

Another area where academics appeared not to be engaging related to the Green Impact programme, which had been introduced at BU in 2015. The programme involves staff working in teams within their departments to complete a workbook of actions covering several aspects of sustainability. The more actions completed, the more points are gained, leading to a Bronze, Silver, Gold or Platinum award. In 2017, four teams gained awards, with three at Silver and one at Bronze but three of the four teams were based in administrative functions, with only one academic team participating since 2015. Efforts to extend the programme have secured an increase in the number of teams (14 teams in 2017/18), however academic teams are still in the minority. Other universities (e.g. the University of Sheffield) have had greater success in securing academic staff participation in the programme, demonstrating that at BU, there is potential for further improvement. A survey investigating the barriers to pro-environmental behaviours at BU, including participation into the green impact programme, highlighted that the biggest barriers facing staff were: lack of time, funding and organisational support (Scarborough and Cantarello 2018). This echoes some of the barriers identified by the National Union of Students (NUS) et al. (2017) in their sustainability in education report. However, it is interesting to note that while time was the most highly reported barrier at BU, this barrier is only listed in position six in the NUS report; this suggests that incorporating green impact participation into staff workload could provide an effective solution for BU to encourage more staff to adopt pro-environmental behaviours and so, where more staff lead through example, more students might be encouraged to follow.

In early 2017, it seemed to be the case that while considerable progress was being achieved in relation to campus greening, community engagement and sustainability research, since achieving ISO 14001, the ESD agenda was lagging; securing staff commitment and interest was continuing to be a challenge. In essence a different approach was required to engage academic colleagues.

6 A Further Shift of Approach: Aligning with the SDGs

As a consequence of ESD being incorporated into the EMS and hence an item on the ‘risk register’, it became an agenda item for the SSG. This was an important turning point highlighting the need to try other approaches. The group evaluated ESD as at ‘high risk’ of not being achieved. The main reason for this decision was the lack of evidence that sustainability had been embedded in courses further obtaining robust and objective evidence to report on the extent to which it had been embedded, was likely to be challenging. Other Universities, such as the University of Winchester, have addressed how to embed and benchmark sustainability in the curriculum by signing up to the NUS Responsible Futures programme which provides a framework for implementing and reporting on ESD (NUS 2017). BU had not participated in such a scheme.

Discussion on how to move forward highlighted the importance of communication that appealed to all stakeholders. Communication of sustainability messages is key to engaging with academics (Djordjevic and Cotton 2011) and to culture change. SSG recognised the potential of focusing communication on the SDGs, as a vehicle to engage with a wider academic audience and to achieve greater adoption of ESD. This decision was based on the assumptions that: all staff might address one or more SDGs in their subjects; the topic might have greater appeal than ESD, given that some staff were unable to relate to sustainability, let alone ESD; others were finding it difficult to understand how their actions today are either directly or indirectly affecting the future of the planet to support human life; others struggled to connect taking personal responsibility for relatively simple actions, such as recycling, with protecting the environment. The SDGs would provide a different lens for people to understand and explore what sustainability means for them, plus the tangible ways they might help make a difference.

The first communication initiative took the form of an adaption of the earlier ESD competition: instead of requesting examples of ESD, academics were asked to submit case studies of where they incorporate the SDGs in their programmes. Disappointingly, the competition had less impact than anticipated but did allow for three excellent winning academic examples to be promoted. These included an academic who teaches Film and TV. She had incorporated the SDGs into two modules and organised sustainable literacy training for staff in the Media and Communication Faculty. Another academic from the same Faculty had incorporated the SDGs into the assessment of a BA Film Language unit where students were required to produce a three minute film and consider the environmental sub-plot. A third academic from the Law Department, illustrated how 'Advanced Criminal Law' was concerned with the United Nation's Goal Peace, Justice and Institutions (SDG 16). Further, in discussing types of gross human rights violations, the Goals regarding Inequalities (SDG 10) and Gender violence (SDG 5) were covered.

In parallel to the competition, it was decided to pursue a more strategic approach. This took three forms:

- Using EcoCampus and the new ISO14001:2015 standard to provide the framework for ESD
- Further and closer collaboration with the CEL Director to ensure ESD was promoted through central communication channels and became an agenda led by CEL
- Using the opportunity of institutional strategy development to embed the SDGs and ensure that they featured during strategy development processes.

As stated above, BU achieved certification to EcoCampus and ISO14001:2004 in 2016, following an external audit. The new version of ISO14001:2015 was launched in September 2015 (International Organization for Standardization (ISO) 2015) with organisations having three years to transition to the new standard. BU achieved the transition at the end of 2017. One of the key changes to the standard, the need to gain greater commitment and leadership from senior management to the EMS, has been of critical importance. This afforded an opportunity to encourage further engagement with senior management. The importance of this clause, which is now a central component of ISO14001:2015, was discussed by the University's Leadership Team as part of implementing the new standard. It served to influence strategic discussion at an opportune moment—the University's "BU 2018" strategy was coming to a close and the new strategy "BU2025" was in development. The perfect opportunity was provided to renew with leaders discussions around commitment to sustainable development but also to introduce the potential of the SDGs.

As a consequence, the new strategy "BU2025" incorporated into an early draft the following statements (Bournemouth University 2018):

(i) Leadership and impact: Enhance our position as a sustainable organisation and manage the environmental impact of our actions.
(ii) Support our staff from all parts of BU and students to take a responsible approach to the environment and sustainable development by:
    - including sustainable development in our programmes and support our staff and students to make responsible choices about their environmental impact
    - bringing together our academic work on environmental sustainability with our approach to the physical environment at BU
    - driving significant worldwide impact on sustainability and the environment through our strategic investment areas.

Leadership for ESD is vital but also requires ownership by the academic community. It seemed important that CEL should be more visible in terms of developing the agenda but also in taking a leadership role. CEL's remit is to provide academics with guidance on curriculum development and excellence in pedagogical approaches, including the use of new technology to enhance the student experience. Further meetings with the Director of CEL served to gain full support for ESD and the SDGs. The CEL Director reports directly to the Deputy Vice Chancellor (Education) providing a strong central pillar for promoting the SDGs throughout BU. Further, in 2017/18, rather than a one-off presentation on sustainable development, CEL agreed that the PGCert in Education would fully address ESD and the SDGs in the Education Policy unit. In developing the pedagogic approach the SDGs would be introduced to participants in week one, considered in other units and become a theme for assessment.

In addition to strengthening the role of CEL, and to extend communications and influence culture change, presentations were made to the four Faculty Education and Student Experience (FESECs) committees with the aim of directly engaging with academic leads in relation to reinforcing the importance of embedding sustainability in the curriculum and introducing the SDGs. Training on the importance of sustainability was also provided to elected student representatives across the Faculties. These students attend programme meetings with academics and thus, they represent the student voice and have the opportunity to comment on and influence what is being taught. At the same time, BU also signed up to and promoted participation in the first "NUS SDG Teach In" which encourages academics to pledge to include the SDGs within their teaching, learning, and assessment on their course(s) during a week in February 2018 (NUS 2018).

The development of the new BU2025 strategy was an iterative process with the opportunity to further embed sustainability and centralise the SDGs to underpin strategy development throughout. The EAUC conference in March 2017, which focused on the adoption of the SDGs, was a very timely opportunity to take stock of what other institutions were doing and consider how BU could use the SDGs to help embed sustainability in all areas of the business. Attendance at the conference enabled BU's Sustainability Manager to provide various inputs based on the SDGs to the Office of the Vice Chancellor (OVC) during the drafting of the strategy, including mapping BU's strategic Fusion model of excellence in education, research and professional practice, against the SDGs. As a result, sustainability became one of the key areas of the new draft strategy. Strategy development at BU is a process of consultation that includes many opportunities for staff participation and stakeholder comments on drafts. Not only did conversations around sustainable development become a wider concern but the SDGs became a noticeable feature of consultation events and staff development workshops.

One of the major changes in the new strategy will be the need to demonstrate the impact of BU's research, education and professional practice. Under the EMS, BU has already evidenced impact, delivering many environmental and social improvements, such as providing two new buildings to the BREEAM 'Excellent' standard, installing photovoltaics, providing an efficient Unibus service (over 1 M passenger journeys in 2016/17) and using the landscaping of the campus to educate students about the medicinal value of plants. The new strategy will commit BU to extend developments to secure further opportunities for staff and students to use the estate as a living lab for health and wellbeing, and sustainability.

Concurrent with strategy development, the SDGs are being promoted through various media (including electronic screens in buildings), workshops and presentations with the aim of raising awareness amongst both staff and students of their importance, but importantly, to highlight collective responsibility for achievement. Both the main staff engagement tools, Green Impact and Green Rewards (where staff are rewarded for taking positive action for the environment and their health and wellbeing), now link directly to the SDGs. For Green Impact, this involves team members demonstrating how they have incorporated the SDGs into their professional practice, teaching or research. For Green Rewards, the various activities are all linked to the appropriate SDGs and so staff are able to see how what they do on a day to day basis contributes, for example, staff receive 400 points if they sign up to the SDG Accord. As of January 2018, 83 people had signed up but numbers are increasing rapidly.

Further developments are currently in the planning stages to accelerate participation and action; evaluation will take place as the new institutional strategy rolls out.

7 Discussion and Reflections

A substantial amount of effort is going to be required on the part of many stakeholders if by 2030, under Goal 4 of the SDGs, all learners will have acquired:

> the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development (United Nations 2015, p. 15).

It is imperative that universities contribute fully to sustainable development and particularly the SDGs. However, making progress on such agendas within higher education settings has always been criticised as a slow process (Sterling et al. 2013) with barriers to be overcome (Leal Filho et al. 2017b). BU is by no means at the forefront of developments but it is currently further along than many institutions, in developing a strategic and holistic approach which began in 2005 (Shiel 2007). Continual progress is only achieved where mechanisms are in place to track the success of initiatives and to develop new course of action and this paper has described some of the steps that are being taken to move forward. Currently actions at BU are evolving with the SDGs referred to frequently in strategy development workshops and becoming a feature of BU2025. It is recognised that further work will be needed to develop indicators to evaluate achievement and impact.

The approach at BU, as might be expected in an institution that has sought a holistic approach from the outset, has exemplified each of the patterns that Barth and Rieckmann (2013) suggest are distinct ways that institutions engage with sustainability:

top down institutional approaches, bottom up, and sustainability as the environmental management of estates (Shiel and Smith 2017). All of these approaches have continued to be deployed in the actions described in this case study.

In less than a year, the process of highlighting the SDGs at BU has served to involve a wider staff base in discussion, in ways that were never achieved when education for sustainable development was the main focus. Building wider engagement is also being reinforced by continual workshops for staff development and for students. Staff development is critical for building capacity (Desha and Hargroves 2012) and the requirements for such should not be under-estimated. Staff development is never completed, it needs to be ongoing to support change and curriculum development (Cebrián et al. 2012). Beyond staff development, it will be important that collaboration with CEL leads to the development of resources that staff will find easy to use, given the strong evidence (Scarborough and Cantarello 2018) that lack of time is an inhibitor. CEL will also need to play a larger role in taking ownership and leading the education agenda, so that it is no longer seen as the work of a few committed champions, exemplifying pedagogic innovation. BU has already started providing examples of where sustainable development and the SDGs are relevant to the curriculum and are in fact, essential to the future career aspirations of their students (the use of the British Academy of Film and Television Arts (BAFTA) carbon calculator by the British Broadcasting Corporation and Independent Television for developing media programmes, for example, requires students to understand sustainable development and carbon). Further examples of the importance of the SDGs for graduate employability are being developed and will support further curriculum change.

Recent progress would not have been achieved without maintaining top management support; it has been critical from the start and throughout the process. Such high levels of continued support might have been challenging, without the success in securing the EcoCampus Platinum award and ISO14001:2015. Placing ESD on the risk register has also served as an important trigger to secure and legitimise initiatives for further action. In turn, strengthening engagement with leaders has also led to a willingness to embrace the SDGs as a strategic concern. The success of the new strategy will depend upon how key performance indicators are selected and monitored.

To date, actions to inspire change have been prioritised over an approach that audits the curriculum to search out reference to the SDGs, through detailed searching of module specifications. While such an approach has been avoided, a better alternative for benchmarking progress may not materialise; eventually, module specification analysis, or a large-scale survey may be unavoidable, and is currently being considered. Albareda-Tiana et al. (2018) present an empirical study exploring the principles and practices linked to the SDGs in the International University of Catalonia curriculum. Their study involved a through analysis of terms related to environmental, social and economic sustainability found in the university curriculum and then in-depth semi-structured interviews with the deans of different faculties. While this is an exemplary approach and other universities may wish to start with a similar study, desk-based exercises carry the risk of consuming considerable time and resources, when efforts deployed in more visible actions, including staff development, might affect greater change.

Green Impact as an initiative has inspired some change, serving to raise awareness of the SDGs and triggering lots of new activities that will enhance environmental management. It is however, to date, not appealing sufficiently to academic teams. Ways will need to be sought to enhance academic engagement. Green Rewards, on the other hand, is a scheme which is engaging all staff across BU, with clear links between activities and the SDGs; to date, nearly 600 staff have signed up (just over 30%). In future, the data will provide an invaluable indicator of the ways that staff are contributing to achieving the SDGs.

In moving forward, in those cases where the SDGs are already included in the curriculum (e.g. M.Sc. Green Economy (an entire programme) and on the final year Globalisation and Sustainable Development unit, at undergraduate level), it will be important that pedagogy seeks to engage students in critical discussion to enable the paradoxes that characterise the larger discourse of sustainable development in educational practice and by extension the SDGs to be explored. Kopnina (2017) illustrates how through the combination of pluralist, participatory, transformative and instrumental ecocentric approaches at three different institutions in the Netherlands (vocational college, undergraduate and postgraduate levels), she was able to stimulate the students' recognition of critique of the most common terms in the SDGs, namely economic development, inclusion and resilience.

It will also be important to enable the transfer of the theoretical concepts mentioned in the SDGs and associated targets, to personal lives and future work contexts and in so doing, encourage individuals to explore the SDGs independently. Crespo et al. (2017) describe how they were able to do that at the University of Vigo (Spain) by introducing a sustainable holistic rubric based on the SDGs targets which was used to assess students' dissertations. This year, at BU, the SDGs have been incorporated into the assignment for the Globalisation and Sustainable Development unit and the authors of this paper will be able to analyse the t extent to which a less time demanding approach compared to Crespo et al. (2017) might still achieve the same result.

As a final reflection, the process of change at BU has taken time but also considerable effort on the part of SSG members but the Sustainability Manager, in particular. Such changes require attendance at numerous workshop sessions and leading the delivery of presentations, as well as being alert to every opportunity to influence conversations with decision makers. Experience has shown that working in partnership with academics, across educational boundaries and university functions, contributes greatly to success; formalising decisions through a strategy group that is chaired by a Deputy Vice Chancellor, gives legitimacy to outcomes.

8 Conclusion

Maintaining momentum with ESD and particularly holistic approaches to sustainable development, poses challenges; those leading the agenda need to be continually evaluating their approaches and instigating new initiatives (Shiel and Williams 2014), or progress may falter. This paper reflects one institution's evaluation of progress, provides a snapshot of the process of change, and highlights initiatives undertaken to develop further engagement. It has shown how the SDGs have captured support to the extent that, they have been used to inform strategic change, and will become a central feature in the new university's strategy. The SDGs have provided a platform to revitalise institutional efforts in relation to ESD and because of their breadth, it is anticipated that wider academic engagement will be catalysed as institutional strategy rolls out. Academics, who previously might have felt that sustainability had nothing to do with them, are already beginning to explore how particular goals resonate with their discipline, teaching and professional practice. The SDGs have enabled a change of focus at BU, which has increased awareness of the university's sustainable development agenda and extended discussion. The impact of efforts will be evaluated in the future.

This paper will be useful to anyone interested in embedding sustainable development within universities, maintaining momentum of such approaches, and developing strategy to embrace the SDGs. Substantial efforts have been required to reinforce the responsibilities of higher education in relation to sustainable development, similar efforts will be required to ensure that higher education accepts its crucial contribution to the achievement of the SDGs. Universities need to ensure that the SDGs are addressed in the curriculum, through research, on campus and in the community. Through outreach activities, universities can influence significant change within their regions. Further research in all those areas will be important. It may be no easier to address the SDGs strategically and in an integrative way, than it has been historically to address sustainable development, so it will be important to evaluate approaches and research the impacts and challenges in different geographical and cultural contexts. Until such time as implementation is commonplace, case studies sharing experience of how the SDGs are being developed will continue to be required.

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Energy Sustainability at Universities and Its Contribution to SDG 7: A Systematic Literature Review

Amanda Lange Salvia and Luciana Londero Brandli

Abstract Considering the importance of the Sustainable Development Goals (SDGs), especially SDG 7, focused on "Affordable and Clean Energy", universities have the role of promoting sustainability through combining sustainable energy with the processes of knowledge transmission and research. Although sustainability at universities has been thoroughly investigated, there is a lack of comprehensiveness in identifying and categorising the university role in energy sustainability and efficiency. In this context, the aim of this paper is to perform a systematic review of the literature on this topic and relate the university role in sustainable development to its contribution to SDG 7. Using the databases ScienceDirect and Web of Science, the review resulted in an analysis of 545 articles from various perspectives, published in the last 10 years regarding energy efficiency and sustainability at universities. This enabled an improved understanding of how universities have been contributing to sustainable development in the energy context and the possibility of exploring scenarios and visions for future actions by educational institutions aiming to comply with SDG 7.

Keywords Sustainable energy · Energy efficiency · Sustainable development goals

1 Introduction

The energy dimension of sustainability is one of the most complex challenges currently (Allouhi et al. 2015; Peñalvo-López et al. 2017; Petinrin and Shaaban 2015), since energy is directly related to national and international security, environmental problems (such as air quality and climate change), as well as the ability to meet

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human needs and promote economic growth (Holdren 2007). The investment in research related to energy sustainability and efficiency is essential due to the current reality of increased energy demand.

An important approach to energy is embedded in the Sustainable Development Goals (SDGs). These goals are an integral part of Agenda 2030, which is a declaration adopted by 193 member states of the United Nations and represents a global plan of action to pursue sustainability in many areas, such as poverty, education, health and climate change, amongst others. Goal 7 (SDG 7) addresses "Clean and Affordable Energy" to ensure reliable, sustainable, modern and affordable access to energy for all. Table 1 presents the targets of this goal and its indicators.

Providing access to different energy sources is a priority, especially renewable, efficient and non-polluting ones. More importantly, it interconnects different contexts, from everyday life to global industrial production, reinforcing the role of educational institutions, through the recognition of education as the main driver in development and research on SDGs (UNESCO 2015).

Thus, universities need to prepare themselves and fulfil their responsibility as trainers to provide graduates with relevant skills and knowledge, taking advantage of their vast potential to implement sustainable measures and build capacities (Anacio 2017; Shiel et al. 2016). Furthermore, university campuses must do more than just act

Table 1 SDG 7 targets and indicators

Targets	Indicators
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	– Proportion of population with access to electricity – Proportion of population with primary reliance on clean fuels and technology
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	– Renewable energy share in the total final energy consumption
7.3 By 2030, double the global rate of improvement in energy efficiency	– Energy intensity measured in terms of primary energy and GDP
7a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology	– Mobilised amount of United States dollars per year starting in 2020 accountable towards the $100 billion commitment
7b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, particularly in least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support	– Investments in energy efficiency as a percentage of GDP and the amount of foreign direct investment in financial transfer for infrastructure and technology to sustainable development services

Source Adapted from United Nations (2016) in a more sustainable way: institutional transformation is necessary, with more active participation by the members of the academic community, increasingly valuing the contribution of education and the curriculum for sustainable development (Lipschutz et al. 2017).

As stated by Lozano et al. (2015), many universities have engaged in and continue to engage in sustainability efforts; however, the implementation of sustainable development has been compartmentalised instead of holistically integrated throughout the institutions, demanding new choices and innovative ways of thinking (Waheed et al. 2011).

According to Leal Filho (2011), universities can contribute to sustainable development with concrete actions in one or more of the following areas: curriculum greening, campus operations, research, extension and concrete projects. However, as all educational strategies, sustainable development in universities can only succeed by aligning information and mobilisation of people to relevant structural measures (including campus greening, robust sustainability research programmes or a set of practical demonstration projects), and the SDGs are supposed to help in this sense as well.

The guide "Getting started with the SDGs in Universities" (SDSN Australia/Pacific 2017) presents how the SDGs and universities can help each other, as showed in Table 2. These opportunities for university engagement in the SDGs can be observed in many recent publications (O'Keeffe 2016; Clifford and Zaman 2016; Albareda-Tiana et al. 2018; Nottingham Business School 2017), through learning and teaching practices, studies on the potential for universities to address cities' challenges, rethinking traditional education approaches, inclusion of SDGs in university reports and in the formal curriculum for all courses, amongst others.

Although sustainability in universities has been investigated through many approaches, with attention to sustainable energy applications, there is a lack of comprehensiveness in identifying and categorising the university role in energy sustainability and efficiency and how it can contribute to the SDGs. In this context, the aim of this paper is to perform a systematic review on this topic and to relate the univer-

Table 2 University engagement in the SDGs

SDGs help universities by	Universities help SDGs by
Creating increased demand for SDG related education	Providing knowledge, innovations and solutions to the SDGs
Providing a comprehensive and globally accepted definition of responsible university	Creating current and future SDG implementers
Offering a framework for demonstrating impact and creating new funding streams	Demonstrating how to support, adopt and implement SDGs in governance, operations and culture
Supporting collaboration with new external and internal partners	Developing cross-sectoral leadership to guide the SDG response

Source SDSN Australia/Pacific (2017)

sity role in sustainable development to its contribution towards SDG 7, as reflected through publications over the last decade.

2 Methodology

The methodology on which the research for this paper is based, followed a three step approach: (a) systematic review and a brief descriptive analysis of the researched articles; (b) classification of the articles according to the approach provided by universities to contribute to sustainable development (SD); and (c) analysis of the interconnection between SDG 7 targets and the role played by universities.

2.1 Systematic Review and Descriptive Analysis

According to Denyer and Tranfield (2009), a systematic review locates existing articles, selects and evaluates contributions, analyses and synthesises data, and reports evidence to allow clear conclusions about the subject. It differs from a literature review due to the fact that it represents a research project that explores a specific question with relevant criteria for selection/inclusion of articles.

In this context, this paper intends to evaluate and synthesise the articles based on the following research question: what is the state of international scientific literature on the theme of energy efficiency and sustainability from the perspective of universities' role?

The search for relevant articles was performed with the aid of scientific literature sources which are representative of academic articles published in peer-reviewed journals. Databases were used to identify all articles published on the topics of energy efficiency and sustainability in universities over the past ten years (2007–2017). The sources of information used to identify the articles for this review were the scholarly databases *Web of Science* and *ScienceDirect*, which provide online subscription-based scientific citation indexing services in many areas, including Energy, Engineering, Environmental Science and Social Sciences. They were chosen for being important databases in these topics and for the ease of collecting the information needed for analysis. Two different search strings were used, including "energy efficiency", "energy sustainability" and "universit*" (to comprise university and universities as well) as keywords to identify scientific articles. The search strings are presented in Table 3 and were defined based on the research question.

The search only considered scientific articles. Books, contributions to edited volumes, conference papers, periodicals, and working papers were not included in this review. According to Podsakoff et al. (2005), this type of publications usually goes through a less rigorous peer-review process and tend to be less readily available.

This and other criteria used to determine the articles that would be included in the review are presented in Table 4. Papers in English, Portuguese and Spanish were

Table 3 Search strings used for the systematic review

Search string 1	"energy sustainability" (topic, abstract, title/abstract/keywords) AND "universit*" (topic, abstract, title/abstract/keywords)
Search string 2	"energy efficiency" (topic, abstract, title/abstract/keywords) AND "universit*" (topic, abstract, title/abstract/keywords)

Table 4 Selection criteria for the systematic review

Criterion	Inclusion	Exclusion
Time frame	2007–2017	Any study published before 2007 and after 2017
Language	English, Spanish or Portuguese	Any other language
Publication type	Peer-reviewed academic journal (Articles)	Any other publication type (e.g. books, contributions to edited volumes, conference papers)
Research area	Energy, Engineering, environmental science, social sciences	Any other research area

considered, although only English keywords were used (Table 2), since both selected databases had abstracts in this language (Caiado et al. 2017). Among the study areas available in the databases, those closest to the research question are Energy, Engineering, Environmental Science and Social Sciences. The inclusion/exclusion criteria were defined based on Schulze et al. (2016) and Caiado et al. (2017).

After the search in the databases, the results were extracted into a Microsoft Excel worksheet. This assisted with the exclusion of duplicates (articles that were found in both databases). Afterwards, articles that were not aligned with the interests of the research or that could be classified as conference proceedings, but that were still somehow included among the database articles, were deleted. It was done by analysing titles and abstracts, as suggested by Schulze et al. (2016).

2.2 *Articles Classification According to the University Role to SD*

A full text analysis was done with the remaining articles, in order to identify the contribution of the university to sustainability in the energy context for each article according to the categories presented by Leal Filho (2011): curriculum greening, campus operations, research and extension. The authors presented one more category (concrete projects), but it was merged with the category "extension", due to the fact that it could be difficult to distinguish both of them from the characteristics presented in the articles. These four categories are aligned with the university contributions to the SDGs presented by the SDSN Australia/Pacific (2017), and Table 5 summarises the theory used for the classification of articles according to their approach.

Table 5 Categories used for articles classification on university role

University role	Examples of approaches/selection criteria
Curriculum greening	Education for sustainable development Training graduates to apply sustainability in their jobs Capacity building courses Mobilising young people
Campus operations	Governance and operations aligned with sustainability Incorporate SD into university reporting
Research	Research on sustainability or related to the SDGs Interdisciplinary and transdisciplinary research Innovations and solutions National and local implementation
Extension	Actions outside campus Public engagement Cross-sectoral dialogue and action Policy development and advocacy for SD External and internal partnerships

Source Prepared by the authors based on Leal (2011) and SDSN Australia/Pacific (2017)

2.3 Interconnection Among SDG 7 Targets and the Role of Universities

Besides the classification made in the steps explained up to this stage, an interconnection between SDG 7 targets and the role of universities towards SD is proposed, based on the review that has been conducted. This interconnection intends to provide evidence of the means used by universities to engage with the SDGs (as presented in Table 2).

After studying the group of selected articles, it was possible to understand how university's actions not only impact on, but also contribute to SDG 7 and help to achieve its targets and indicators (Table 1).

3 Results

3.1 Systematic Review and Descriptive Analysis

The entire search process is shown in Fig. 1. The total number of articles located in the databases numbered 1617 (893 from Web of Science and 724 from ScienceDirect). After exclusion of duplications and articles not related to the research question, 545 scientific articles remained that were considered eligible for the analysis.

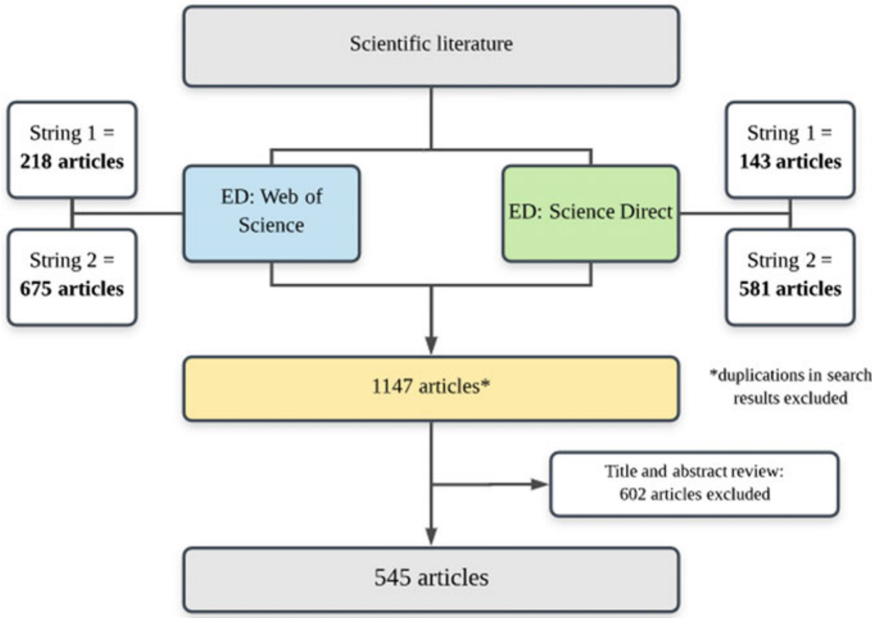

Fig. 1 Mapping the systematic search for articles. *Source* Based on Schulze et al. (2016)

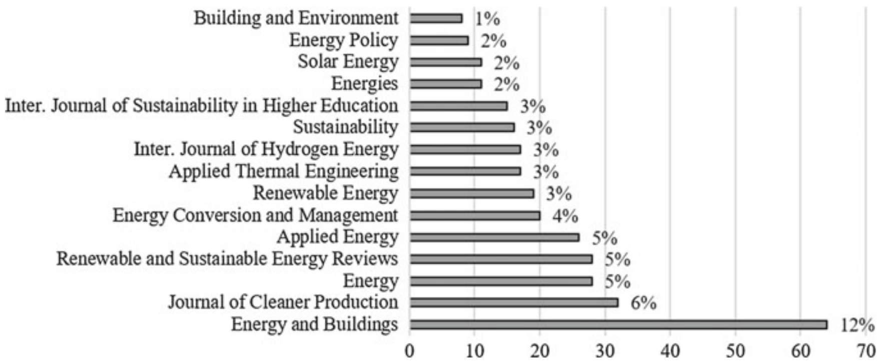

Fig. 2 Number and percentage of articles per journal

The 545 analysed articles were published in 149 different journals. However, almost 60% of these articles were distributed over 15 main journals, as presented in Fig. 2. The other sources represent less than 1% in terms of articles published.

The journal "Energy and Buildings" was the leader, with 64 articles, representing 12% of the total. Following are "Journal of Cleaner Production", "Energy", "Renewable and Sustainable Energy Reviews" and "Applied Energy", with an average of approximately 30 articles published in each.

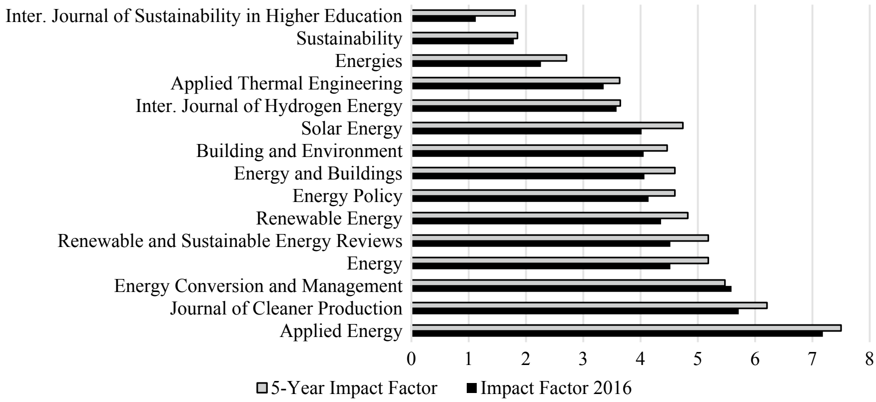

Fig. 3 Impact factors of the 15 main journals

As suggested by Caiado et al. (2017), the relevance of the articles according to the impact factor of the journals can be measured by the Journal Citations Report (JCR), which is published annually by Thomson Reuters. Since it is a parameter used worldwide to assess the relevance of scientific production, Fig. 3 presents the impact factor of these 15 journals (in 2016, the last year available at the time this chapter was written), as well as an average of the last five years.

As far as the impact factor in the academic community is concerned, the most prominent journal is Applied Energy, with an impact factor of 7.182 in 2016 and an average of 7.500 over the past five years. Connecting this analysis with the data from Fig. 2, it is important to highlight that along with "Applied Energy", the 4 main journals in terms of number of articles also have a significant impact factor over the past five years, especially the "Journal of Cleaner Production" (6.207).

Figure 4 provides an overall picture of the number of articles published and its percentage per year. The analysis of this systematic review shows an increase in the number of articles between 2007 and 2017. In 2007, less than 20 articles were published, whilst almost 120 articles were distributed to the academic community in 2017. Furthermore, the last three years have more than half of all publications, which confirms the increasing importance of the topic of energy sustainability and efficiency at universities.

3.2 *Classification of Articles According to the University Role in SD*

After the descriptive analysis, a deeper analysis followed. The 545 articles were classified according to the role performed by universities to achieve sustainable develop-

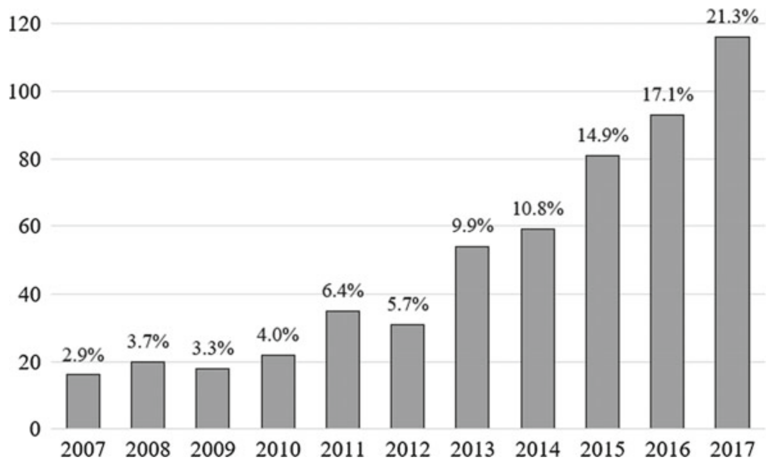

Fig. 4 Number and percentage of articles over the past years

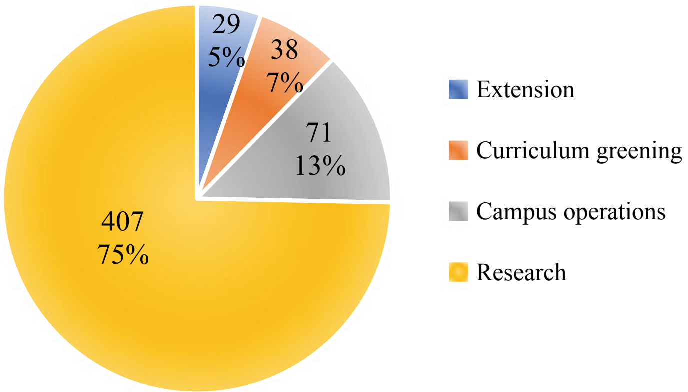

Fig. 5 Proportion of articles classified according to the university role in SD

ment (SD): extension, curriculum greening, campus operations and research. Figure 5 illustrates the proportion and number of articles according to this classification.

The articles classified as "extension" are those dealing with universities involved with continuing education or further education programmes, as well as actions or studies performed by universities beyond their direct locality—i.e. broadening actions to the community, companies and the household sector, amongst others (Bambawale and Sovacool 2011; Sadineni et al. 2012; Staller et al. 2016). Among the 545 articles, 29 (5%) were considered examples of extension.

"Curriculum greening" included articles that presented changes in the university curriculum, such as inclusion of new subjects, discussions about sustainability in class, practical classes or other activities or actions (Alawin et al. 2016; Desha and Hargroves 2010; Jain et al. 2013). In other words, these articles presented ways

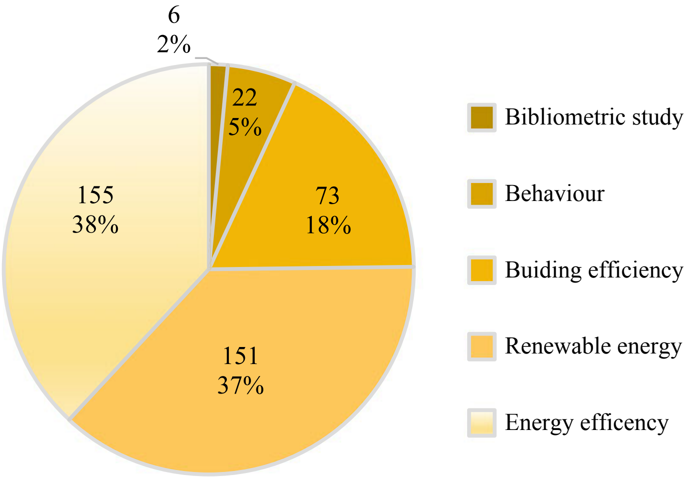

Fig. 6 Proportion of articles classified as "research"

developed by universities to include energy sustainability and efficiency in their teaching processes. In this systematic review, 38 articles (7%) were classified as presenting evidence of curriculum greening.

Another role is to contribute to SD through "campus operations". In this case, universities invest in themselves in order to promote awareness, efficiency and working in a living lab for students, employees and the community (Kalkan et al. 2011; Kolokotsa et al. 2016; Mytafides et al. 2017). In total 13% of the articles included in this review presented evidence of "campus operations".

"Research" is another important role that universities has to play in SD. This is because research is one of the pillars of universities, seeking to investigate phenomena and to create the knowledge required to promote societal changes, besides creating opportunity to exchange knowledge, methods, experiences and knowhow (Berchin et al. 2018; Mills and Schleich. 2012; Sesana et al. 2016). Approximately 75% of the reviewed articles represent studies related to "research" in the energy sustainability or efficiency context.

This notable contribution of "research" as a university role necessitated further investigation. The research presented in the articles was therefore further categorised in terms of the following: bibliometric study, human behaviour, building efficiency, renewable energy or energy efficiency. The last four categories represent common research areas in the energy context, while bibliometric study was included since articles on this topic were not so easily framed within the context of the other areas. As shown in Fig. 6, a total of 407 articles were further subdivided according to this classification. This subdivision was also used to prepare Fig. 7, showing a breakdown per year of the number of articles published according to this classification.

Only 6 articles presented bibliometric studies. They were about the scientific production of renewable/alternative energy and energy efficiency over the past few

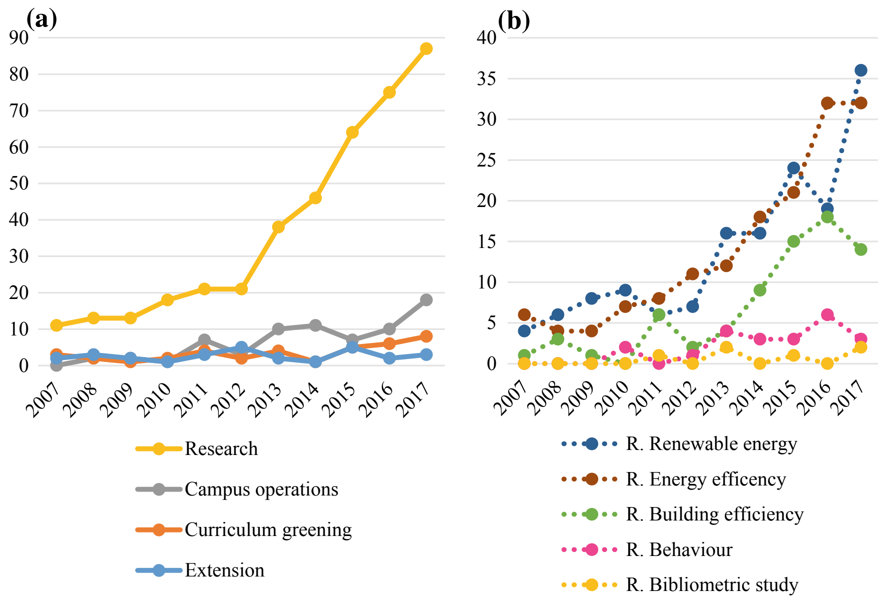

Fig. 7 Number of articles published per year according to their approach

years. Another relatively small group of articles (22) was classified as research about behaviour with reference to the energy context. The main focus areas in this group of articles are about the role of individuals and their engagement regarding energy conservation attitudes and knowledge, behaviour changes and consumption habits, pro-environmental and energy behaviour (Fernández et al. 2016; Kaplowitz et al. 2012; Pothitou et al. 2017). Both bibliometric and behaviour studies had their first publications after 2010 (Fig. 7b).

A larger number of articles were observed in the category of energy efficiency research in the building sector. In total 73 articles focused on matters related to energy performance in buildings, LEED certification, green buildings, framework assessment of energy efficiency or energy use (Agdas et al. 2015; Asdrubali et al. 2013; Chokor et al. 2015). Between 2012 and 2016, the number of articles of this kind increased noticeably.

Renewable energy and energy efficiency are the research areas with the largest number of articles in the whole analysis: 151 and 155, respectively. They stand out in Fig. 7b, with their significant increase in number of published articles over the past ten years. When it comes to renewable energy, the articles present many different approaches, including wind, solar, ocean and thermal energy, biomass and biofuels production and hydrogen energy systems, amongst others. Most of these are experimental studies, seeking to improve the use of renewable energy resources or their performance evaluation (Cotana et al. 2016; Lee et al. 2016; Salem et al. 2017). The articles are under the energy efficiency classification are more varied—they include actions to reduce economic costs and increase economic returns to investment; to provide energy security; to reduce energy waste and the amount of primary energy resources used; besides assisting to mitigate global and local environmental impacts, such as greenhouse gas emissions (World Bank 2007; Bunse et al. 2011). In summary, the articles in this category described energy savings opportunities at universities or in other sectors, energy efficiency in processes or products, modelling and simulations to reduce carbon emissions in energy systems, amongst others (Aris and Bhaskoro 2014; Lau et al. 2014; Unachukwu 2010).

3.3 Interconnection Between SDG 7 Targets and Role of Universities

The results so far present evidence of the ways that universities have been contributing to SD in the energy context and, therefore, it is possible to connect each area of action to the SDG 7 targets, as indicated in Fig. 8.

Target 7.1 is about energy access and has two indicators: proportion of population with access to electricity and proportion of population with primary reliance on clean fuels and technology. Universities tend to contribute to this goal by their actions in *curriculum greening*—by cultivating a new generation of professionals, technically prepared to work in this matter; *extension*—by performing concrete projects in collaboration with or for communities; and *research*—by searching for more efficient ways to provide energy and improving modern technologies.

Target 7.2 encourages the use of renewable energy. It can be measured by determining the share of renewable energy in the total final energy consumption. In this context, universities could play a role through *campus operations* or *extension*—when renewable energy is used in academic buildings or through providing this type of opportunity to communities as well. It can also be through *curriculum greening*—by using existing technologies on campus to teach or by including more subjects related to renewable energy in class. In the last instance, it can be through *research* (i.e. bibliometric study, energy efficiency and renewable energy)—by understanding older and new studies and by investing in methods to improve the efficiency of renewable sources.

Increasing energy efficiency is the specific aim of Target 7.3, for which the indicator of energy intensity is measured in terms of primary energy and GDP (Gross Domestic Product). Since energy efficiency is related to many aspects (such as economic costs, energy security, energy savings and carbon emissions) all actions performed by universities connect directly to this target, except *research* on bibliometric studies, since its contribution is not that applicable.

The following target, namely 7a, seeks to enhance international cooperation, and is measured by financial investments. Universities could contribute while investing in *curriculum greening* (by teaching students the importance of mobilisation and cooperation) and *extension projects* (by applying this cooperation, at least in the context

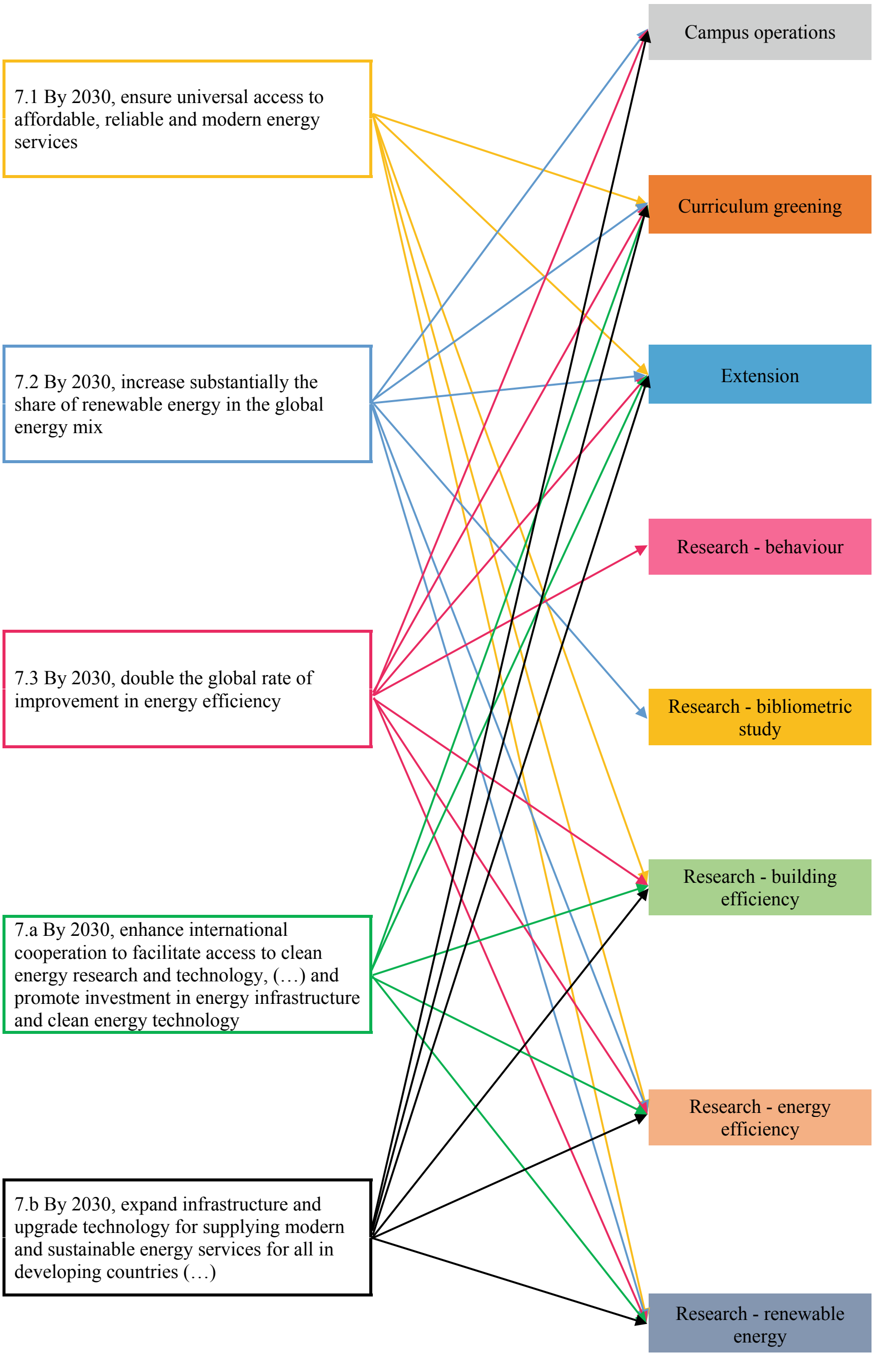

Fig. 8 Interconnection between university's actions and SDG 7 targets

of local realities). *Research* on building efficiency, energy efficiency and renewable energy is also a positive approach, since these could lead to more efficient and maybe cheaper ways to provide energy infrastructure and clean energy technology.

The last target, namely 7b, focuses on expanding energy infrastructure and upgrading the technology used, and is also measured by financial investments. The role of universities in this context is the same as described for the previous target. Besides these actions, investment in *campus operations* is also a positive way to contribute, since academic buildings with good energy plans could represent models to define related strategies to cities and buildings of other sectors.

4 Conclusions

The aim of this paper was to perform a systematic review of the literature on energy efficiency and energy sustainability at universities and relate their role to SD and its contribution to SDG 7. The databases used were ScienceDirect and Web of Science.

The research question was "what is the state of international scientific literature on the theme of energy efficiency and sustainability from the perspective of universities' role?" A group of 545 articles was analysed in this review, representing examples of the university role in energy efficiency and SD.

According to the results of this analysis, research is the main area that universities have been using to contribute to sustainable development in the energy context. Although this type of research is not always implemented rapidly and does not always lead to direct results, it is constantly working toward improved results and better learning. This kind of systematic review is also important to show the extent in which the researches are working, so that university teams can be aware they integrate a whole community that works with this subject around the world.

Regarding the role of universities, it is important to note that this review points out that not only energy efficiency and sustainability could be improved, but that more attention should be paid to other areas as well, such as curriculum greening, campus operations and extension. It indicates that universities could engage more, for example, in capacity building courses, mobilising young people, aligning sustainability to its governance, promoting more actions outside campuses, public engagement and policy development for SD.

There are many published articles using systematic reviews on energy, but this paper intended to contribute to this field of research by connecting energy publications about the role of universities in promoting SD and to explicitly show how university actions can contribute to achieve SDG 7 targets and consequently their potential to help meet this goal.

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The Role of Green Areas in University Campuses: Contribution to SDG 4 and SDG 15

Luciana Londero Brandli, Amanda Lange Salvia, Vanessa Tibola da Rocha, Janaina Mazutti and Giovana Reginatto

Abstract Considering the importance of green areas for sustainability, universities have great potential to contribute to it while improving the use of green spaces in their campuses. By doing so, universities are also contributing to the Sustainable Development Goals, especially SDG 15, which seeks the protection of forests and biodiversity and their sustainable management, and SDG 4, which aims to ensure qualitative education, by promoting a culture of environmental awareness in students. Thus, this paper aims to highlight the role which green areas in university campuses play in the promotion and integration of SDGs 4 and 15, based on a case study carried out at the University of Passo Fundo (UPF), located in South of Brazil. UPF stands out among other universities in the region due to its great availability of green areas, but the academic community needs to make sustainable use of these spaces. The study evaluated the perception of the university community regarding green areas, to analyse how UPF explores these environments and to study strategies to enhance its use. The results showed that the university has been exploring its green areas by promoting events in favour of the local and academic community, however, more actions could be applied to take advantage of the campus' ecological potential. The case study confirmed how the green areas in university campuses can contribute to and interact with the SDGs, especially through management actions.

Keywords Sustainable development goals · University campus · Education · Green areas

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1 Introduction

Green areas are recognized as important spaces both for improving the quality of life of the population that integrates it and for the sound maintenance of an entire ecosystem that depends on it. Over the years, the importance of preserving areas with remnant of vegetation cover has remained undisputed, especially considering their functions and cases of degradation.

Since university campuses tend to have rich green areas, they represent important allies on the promotion and practice of sustainability and the sustainable use of green spaces. The optimization of the green areas of a university campus, with the purpose of promoting sustainability, meets the theme of the new global agenda. 2030 Agenda emerges as a plan of action that seeks to achieve human rights through 17 integrated goals, the Sustainable Development Goals (SDG). These goals are to promote a socially just, environmentally appropriate and economically viable world, thus consolidating the basis for sustainable development to occur and were designed to conclude the actions initiated in the 2000s with the Millennium Development Goals (United Nations 2015a).

Universities can contribute to the integration of SDGs by emphasizing local and regional projects in the field of sustainability. Also, by sensitizing university students to practical experiences, the university is making clear the need for personal involvement and action (Leal Filho 2011).

SDG 4 aims to ensure qualitative education, providing lifelong learning opportunities for all and aims to ensure that by 2030 all students are able to promote and experience sustainable development (United Nations 2015b). The sustainable development education proposed by this SDG addresses issues such as the relationship of global citizens with nature and learning at all levels of education, including higher education, since between 2000 and 2013 enrolment in this type of education has doubled globally (United Nations 2016). SDG 15 seeks to protect forests and biodiversity so that these natural resources can benefit everyone, including future generations. Among its goals up to 2020 are the promotion of sustainable use of these areas, increasing afforestation and reforestation, and combating the degradation of natural habitats (United Nations 2015c).

When developed together, these two goals can be even more successful, since the main tool for raising ecological awareness and subsequent environmental protection is education for sustainable development. So, as you work on one goal, positive contributions also emerge in others.

In this context, integrating sustainable actions related to quality education (SDG 4) and preservation of terrestrial life (SDG 15) requires assistance from the university environment as a key factor for the mobilization and awareness of individuals capable of contributing to a better future.

For universities to comply with their role of integrating these SDGs and their own goals, they must be motivated and prepared to train professionals to work in the related areas of sustainable consumption, soil conservation, climate change, preservation of terrestrial ecosystems, among others (Beuron et al. 2017).

Fig. 1 Main Campus area at Passo Fundo, in 2016 (University of Passo Fundo 2017a)

The University of Passo Fundo (UPF) is a community university that stands out as a regional pole of teaching, research, extension and technological innovation in southern Brazil. Among the 195 Brazilian universities, public and private, UPF is one of the best 90, based on indicators of research, internationalization, innovation, teaching and market (Ranking Universitário Folha 2016). Nowadays, the university contributes to the formation of 17,684 students enrolled in 143 undergraduate and postgraduate courses. The main campus area, visible in Fig. 1, is approximately 35.5 ha and hosts 4100 species of 102 different native, exotic and endangered tree species (Melo et al. 2015).

Within this context, this paper aims to highlight the role which green areas in university campuses play in the promotion and integration of SDGs 4 and 15, based on a case study carried out at the University of Passo Fundo—Brazil.

2 Literature Review

By definition, green areas are places where arboreal vegetation is predominant, with 70% of vegetal cover in permeable soil, and where several ecological, aesthetic and leisure functions are promoted (Rosset 2005; Rubira 2016). Among the ecological functions that these natural compositions play, are: the maintenance of the water cycle; the capture of carbon dioxide from the atmosphere, and consequently the release of oxygen; mitigation and adaptation to extreme events related to climate changes (such as high temperatures and floods) and increased soil fertility through root retention (World Bank 2017). In contrast, replacing these areas with paved areas may contribute to flooding and the effect of heat islands in cities (Melo et al. 2015).

Besides that, the decline of these spaces in urban environment limits the opportunities of experiences and exchange of knowledge between the new generations and the nature (Speake et al. 2013). Given that promoting sustainability by encouraging people's contact with nature is easier than motivating them to behave in an ecologically sustainable way (Nisbet and Zelenski 2011), the phenomenon of green areas decrease in the urban environment is becoming problematic. The projections of the World Urbanization Prospects report show that by the year 2050, 66% of the world population will be living in the cities (United Nation 2015d) and to meet the challenges of world population growth, an adoption of a sustainable way of living is urgent.

Sustainability is defined by Moore (2005) as a concept that permeates the spheres of social justice along with ecological integrity, considering the well-being of all living systems on the planet. Another definition found is the one of applied sustainability, given by Leal Filho (2011), who sees sustainability as a way to approach and guide actions in real contexts and situations applying the principles of "Sustainable Development". This term was conceived in 1987 by the United Nations' (UN) World Commission on Environment and Development and means "to meet the needs of the present without compromising the ability of future generations to meet their own needs" (UN 1987). These concepts converge to the central idea that everyone has the right to live in an ecologically balanced environment (the right of the latter, which is provided for the Constitution of the Federative Republic of Brazil of 1988), and for that, conscious use of the natural resources of the planet is necessary, avoiding its capacity of support to be exceeded and ensuring that the next generations also have right to its use.

In "Higher Education in a Warming World" of Eagan et al. (2008), the role of universities as propellers of actions aimed at a sustainable world is highlighted and emphasized by the fact that these institutions will form the leaders of future societies. These spaces are people-trainers, disseminators of values and knowledge, who can convert a theoretical concept of sustainability into real behaviour through the promotion of actions (Finlay and Massey 2012). In this context, Higher Education Institutions (HEIs) are at a unique position on promoting sustainable development, because the role of universities, in the lives of future global citizens, is not limited to the educational/vocational sphere. Universities are also the place where consolidation of social values takes place. Authors such as Katiliūtė and Staniškis (2017) argue that the duty of HEIs is not only to train their students, but also to encourage the commitment of the academic community to sustainability and, this way, universities are able to offer students learning and awareness, contributing to what can be described as lifelong learning.

In addition, for Thomashow (2014), when the ecological potential of a university campus is recognized, the first step towards understanding and practicing sustainability is taken, and at this point the university campus becomes a green campus—an educational and scientific space where the problems of the world are discussed at the same time as the search for solutions is encouraged. It can be said, therefore, that the university "green campus" works towards being innovative and a pioneer on the search for a sustainable future. In order to achieve this sustainability in a university, Thomashow suggests nine key elements, allied to goals that must be reached on a campus. In this case study at University of Passo Fundo, it is possible to highlight the presence of some of them, like the incentive to local agriculture, leadership to engage people in the pursuit of sustainability, environmental comfort, union of the built environment with the local ecosystem and wise exploration of the landscape.

In the view of Bortoluzzi et al. (2004), the large circulation of people opposing the vast and exuberant landscape of a university campus is the guarantee that the benefits produced in this environment are ecological, social and economic. Tzoulas et al. (2015) says that when universities disregard the ecological potential of their campuses, these socio-economic and environmental benefits can be lost, and also affirms that biodiversity is a key element in the sustainable development of university campuses.

Xypaki (2015) describes some successful practices that occur in the Green Dragons university city and that can be used in SDGs 4 and 15. Some of the practices are: to promote sustainable livelihoods in campuses, to have students and communities committed to projects aimed at reducing environmental impacts caused by campus activities, and to encourage sustainable trade and ethical procurement. All these alternatives are actions that promote a sustainable culture among academics and go far beyond the implementation of disciplines with the environmental theme in the curriculum. Therefore, student engagement is developed in a practical way and becomes a key factor for students to experience sustainability and to be able to promote it locally.

Based on this, it is evident that universities can contribute to the dissemination of a sustainability culture, locally, by optimizing the green areas of their campuses.

3 Methodology

The main campus of University of Passo Fundo is located in the city of Passo Fundo, in Rio Grande do Sul state—Brazil (Fig. 2) and, due to the great regional visibility of the institution, its actions reach a significant extent in the state. In addition, given the vast ecological potential of the green areas of the campus, it can be considered a living laboratory for social and environmental practices, which contribute with experiences and learning to the users (Melo and Severo 2007).

The paper methodology followed the steps below:

Step I: primary data collection, through elaboration of a questionnaire with questions regarding the use of green spaces at Campus I of the UPF, that was made available to students, professors and employees of the institution;
Step II: gathered information about the way the institution explores these spaces through the promotion of events on campus using the institutional website of the university as a search source;

Fig. 2 University location in Latin America

Step III: search for good practices adopted by US and Canadian Higher Education Institutions for the valuation of green spaces on university campuses based on the guide The College Sustainability Report Card.

3.1 Questionnaire

According to Step I and with the objective of analysing the environmental perception of campus visitors regarding the green areas and the physical conditions of this space, a questionnaire was prepared and sent to students, professors and employees of the University of Passo Fundo through the institutional e-mail. In total, 18,049 users received the questionnaire, 15,990 (88.6%) of whom are undergraduate and graduate students and 2059 (11.4%) are professors and employees.

The questionnaire was organized with a total of seven questions, five of which were closed ones. The second last question evaluated the infrastructure of the green areas for the items: furniture, accessibility and visual communication and the answers were measured using a 5-point Likert scale, ranged from 1 (totally disagree) to 5 (totally agree). The last question asked the respondent to describe their opinion on what the university could do to improve the use of green areas in a sustainable way. Table 1 describes the questions asked to the survey respondents.

The questionnaire was available to the participants from December 12, 2017 to January 17, 2018. The percentage of responses was higher among the university employees (13.6%) and lower among the students (3.1%). Overall, the response percentage was 4.3%, representing a total of 768 responses received, according to Table 2. However, this result was expected by the researchers since the low rate of return (responses) is considered one of the main disadvantages of online surveys, according to Vieira et al. (2010).

The first three questions were important to identify and characterize the sample of respondents. The others were prepared following the research interests, with a questionnaire structured with punctual and quick questions. In a similar approach, Magro (2006) and Speake et al. (2013) presented topics and questions related to the ones chosen for this research.

Table 1 Questions of the questionnaire

Question description		
1	You are: (student, professor or employee)	
2	If student, which is your course?	
3	If professor or employee, which is your academic unit?	
4	How often do you use the green areas of the campus?	
5	Which environment (green space) do you use most often?	
6	Which activities do you develop/participate at the green areas of the campus?	
7	Mark from 1 to 5 (being 1 the totally disagree item and 5 totally agree according to your opinion on the statements made) and evaluate the green area infrastructure	THE FURNITURE: presents adequate and sufficient seats
		THE FURNITURE: presents adequate and sufficient dustbins
		THE FURNITURE: presents adequate and sufficient lighting
		The ACCESSIBILITY: presents paths, tours and routes of easy access and inviting to use
		The VISUAL COMMUNICATION: presents identification of trees according to their species
		THE VISUAL COMMUNICATION: presents signs/identification of the green spaces inside the campus
8	In your opinion, how could the institution utilize better the potential of the green areas of campus I?	

Table 2 Feedback percentage

Search group	Number of participants	Number of respondents	Feedback %
Students	15,990	489	3.1
Professors and employees	2059	279	13.6
Total	18,049	768	4.3

3.2 Events Promoted by the Institution at the Green Areas of the Campus

According the proposed methodology, the second step was a search made on the institutional website of the university in order to verify how the green areas are being used. In the search, 30,825 news items were verified, from June 24, 2002, when the site began, until December 31, 2017 (University of Passo Fundo 2017b). The events considered in this search were those that occurred in the green spaces of the main UPF campus.

3.3 The College Sustainability Report Card, 2011

On the third step, based on the latest available version of *The College Sustainability Report Card*, best practices applied in American and Canadian universities were searched. *The College Sustainability Report Card* was a comparative guide/report card to sustainable practices in Higher Education Institutions (HEIs) on the United States and Canada. It was developed by the Sustainable Endowments Institute, and generated the *Green Report Card*, a report that analyses these HEIs at the perspective of sustainability (Sustainable Endowments Institute 2011a).

The last edition of this report, made available in 2011, analysed 322 institutions (http://www.greenreportcard.org/report-card-2011/schools.html). This material was chosen to serve as a basis, since the document provides a detailed profile of each institution considering 52 indicators related to good sustainability practices in relation to campus operations and the policies adopted by the institutions. In addition to discovering the actions promoted by other institutions, the research in the Green Report Card contributed to the identification of good practices that can be adapted to UPF to improve the use of the green areas in its campus.

4 Results and Discussions

4.1 Perception of Survey Participants in Relation to Campus Green Areas

The first question of the questionnaire characterized the profile of the respondent, which could be: student, professor and employee. Most of the respondents were students (63.7%), counting 489 answers, followed by employees (22.5%) with 173 answers, and lastly by professors (13.8%) with 106 answers. The greater participation of students, when compared to the other two groups, is justified by the greater proportion of individuals in the total sample (15,990).

The next question (according to the participant's profile) requested identification of the academic course (for students) and academic unit (for professors and employees). Figure 3 illustrates the description of the courses, in which the students participated with the greatest number of answers (Appendix 1 describes all the academic courses that participated in the research and Appendix 2 describes the academic units).

According to data from Fig. 3, the courses that participated in the survey with the highest number of respondents were: first, the Civil Engineering course (12.9%); then the Architecture and Urbanism course (7.4%) and, thirdly, the Postgraduate courses (6.5%). There was a low rate of participation of academics in other courses. It is noted that the students have not yet understood the importance of their engagement to achieve the goals and actions that involve sustainability, confirming the lack of empowerment and awareness in most of the young people in the world when it

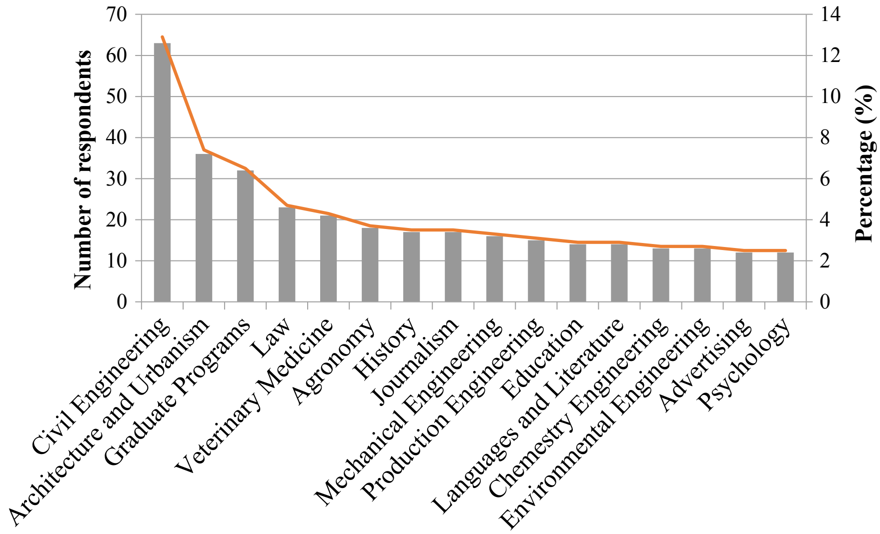

Fig. 3 Major participation of respondents, according to their academic course

comes to their role in the society and the obstacles posed by the twenty-first century (UNESCO 2017).

Figure 4 shows the participation of university's professors and employees. The academic units that participated the most were: administrative sector (22.6%), professors and other employees of Faculty of Engineering and Architecture (12.5%). Also, 10.4% of the participants in this group (professors and employees) did not inform their academic unit - but their results were incorporated in the analysis. According to results presented in relation to the participation rates of professors and employees, it is evident that the Faculty of Engineering and Architecture is engaged in the research in question, since the academics of this unit also presented the highest participation rates (see Fig. 3).

The fourth question asked if and how frequently the interviewees use the green areas of the campus. 94% of the participants stated that they use the green areas; 64% of them mentioned that they use these areas "sometimes" and 30% say they make "daily use" of these spaces. Only 6% of the respondents said they never use the green areas of the campus. The positive feedback in terms of use of green spaces on campus reinforces the university's need to conserve these areas as well as to stimulate their frequent use in a sustainable and educational way.

Table 3 presents the use of green areas by profile. Based on our sample, we could notice that employees use the green areas very often, more than expected (in comparison to the students group), which is a very positive response. The main reason for that, relating to other groups, is that most part of the employees stay at the Campus during mornings and afternoons, while many students and professors tend to go to the university only at night.

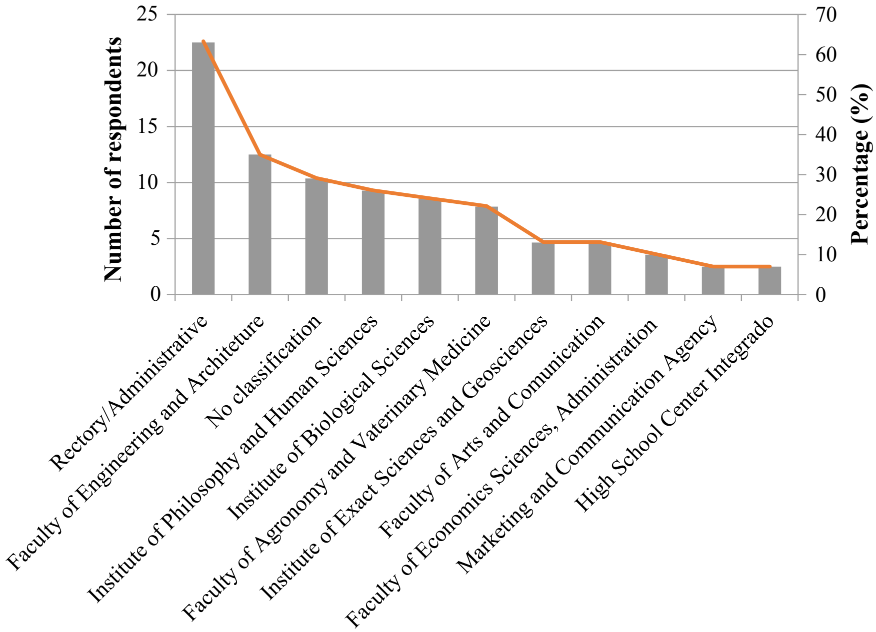

Fig. 4 Feedback of professors and employees by academic unit

Table 3 Use of the green areas by profile (percentage)

Frequency	Total (%)	Students (%)	Professors (%)	Employees (%)
Daily	30	28	11	48
Sometimes	64	65	81	49
Never	6	7	8	3

Regarding the fifth question, "Which environment (green space) do you use most often?", six of the campus's main green areas were suggested as answers, according to Table 4.

It is important to note that the results exceed 100% because the respondents could identify more than one green area. In addition to the areas mentioned in Table 4, other areas were described by less than 1% of the respondents: Faculty of Arts and Communication (0.3%) and CEPA (0.1%) and Science and Technology Park UPF (0.1%).

The sixth question of the questionnaire was: "Which activities do you develop/participate at the green areas of the campus?". The participants could select from the options described in Table 5. The most pointed activities were observation and reading.

Important differences in most used areas were not evidenced in the analysis per profile. Students, professors and employees also present similar behaviors when it

Table 4 Most used green areas

Green area description	Total (%)	Students (%)	Professors (%)	Employees (%)
Living center	79	82	72	79
Central library	40	43	42	34
Eureka's restaurant area	11	11	12	10
Sports' areas of faculty of physical education and physiotherapy	7	7	9	8
Areas of the extension center and Agropecuary Research—Cepagro	6	8	8	1
Areas of the natural heritage and private reserve	5	6	8	3

Table 5 Activities developed at the green areas of the campus

Activities	Total (%)	Students (%)	Professors (%)	Employees (%)
Observation	66	70	60	61
Reading	37	44	25	25
Photography	16	16	12	16
Sport	16	11	24	24
Events	12	9	11	21
Classes	8	11	10	2
Trails	4	4	9	3
Expositions/fairs	4	3	8	8
Researches/experiments	4	5	6	2
Dance	4	0	1	0
Other activities[a]	4	7	17	16

[a]Respondents described the following: rest, leisure, among others

comes to most common actions developed; however, it was observed that in comparison to the other groups, students use more the areas for reading, while employees use more for participating in events and less for classes, as expected.

In the seventh question, using the Likert scale, the respondents evaluated statements, according to their perception, about the infrastructure: seats, dustbins, lighting, accessibility, identification and signalling, as shown in Table 6.

When respondents were asked if the seats inserted in green areas of the university were adequate and sufficient for use, 52% disagreed (totally or partially), emphasizing the need to improve their availability. This is because UPF's Campus I has a large extension of green areas and currently does not show great availability of this urban furniture. Similar opinion was observed analysing the perception per profile.

Table 6 Infrastructure perception

Infrastructure	Likert scale				
	Totally disagree (%)	Partially disagree (%)	Not agree neither disagree (%)	Partially agree (%)	Totally agree (%)
Seat	20	32	32	13	3
Dustbin	12	24	29	24	11
Lighting	13	25	30	23	9
Accessibility	5	13	22	33	27
Identification	48	26	16	6	4
Signalling	32	25	26	11	6

About the following topic, that "Green areas have adequate and sufficient dustbins for use", 36% of the respondents disagreed and 35% agreed with the statement. The answer might depend on the area that the respondents use more frequently (in fact, employees presented a higher agreement percentage than the other groups), but the result emphasizes the need for more dustbins, providing care with the green spaces.

Regarding campus lighting, most part of the respondents (38%) disagreed with the quality, emphasizing that the furniture of the green areas needs to be improved and that the lighting of these spaces should be appropriate to their use in different shifts, giving people security and comfort regardless of the time of day, inside the university campus. Similar percentage of disagreeing was given by students and professors (42 and 32%, respectively), but employees had a more emphatic opinion about it: 69% disagreed with the lighting quality.

When it comes to accessibility, 60% agreed that the campus has easy access roads to the community, including those with disabilities (physical and visual), with similar results in all groups. This shows the satisfaction and recognition of the investments in accessibility that the institution has been making on campus, as well as other research and extension projects that the university carries out in this infrastructure.

The visual communication at the green areas of the campus can be considered the item with the greatest need of adaptation, because most part of the respondents were dissatisfied with its current absence (regardless the profile), thus revealing lack of identification of the species present in the green areas. This is because species' knowledge contributes to the environmental education of users (SDG 4) and stimulates their awareness of the need for proper management of species in an ecosystem (SDG 15).

Finally, the eighth question "In your opinion, how could the institution better utilize the potential of the green areas of Campus I" allowed the respondents to describe their suggestions. After analysing the 768 answers, it was verified that among the main recommendations of the users of the green areas are: improve furniture availability, adequate lighting for the use of green areas at night, greater quantity of dustbins and signs with the identification of tree species present in the green areas. With all these suggestions, there would be greater contribution to achieving

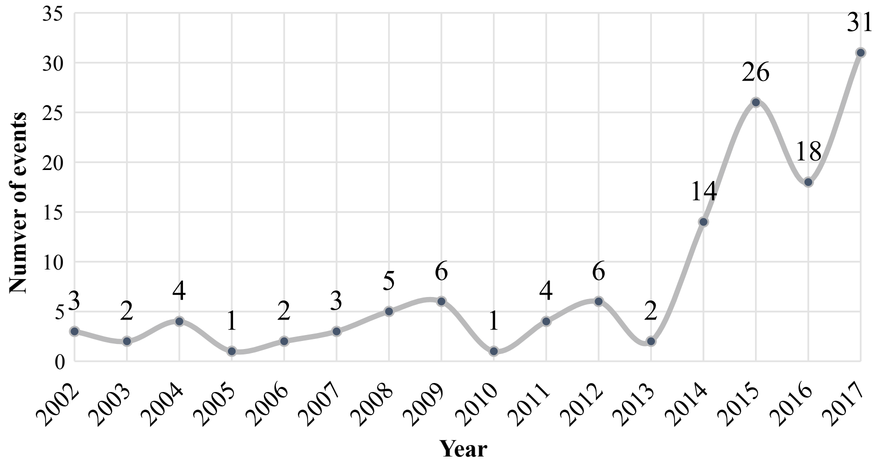

Fig. 5 Occurrence evolution of the events at the green areas of the campus

questions linked to SDG 15 (Bridgewater et al. 2015), especially by encouraging more interaction between the academic community and the green areas.

4.2 Events Promoted by the University in the Green Areas of the Campus

Over the last 15 years, the events held by the institution in the green areas of the campus have increased and were mostly focused on serving the local community, as shown in Fig. 5. It shows not only a gradual intensification on the promotion of events over the last 15 years, but also a significant increase in occurrence from the year 2014, which registered a 7-fold increase in relation to the previous year. To identify the events that contributed most to this increase, Fig. 6 was elaborated, presenting the evolution of events by theme.

According to Fig. 6, the increase of the events registered in 2014 was justified by the occurrence of several events and the *Arte & Literatura* Project, both destined to the local community. Still, the Farm Markets (with ecological and solidarity economy fairs) that reached the end of 2017 with 12 events, reveal the growth of a "sustainable trend" by the institution and its academics who started to buy organic products. Table 7 describes the percentage of occurrence of events by theme.

The most frequently promoted events are the ones classified as miscellaneous; second is the *Arte & Literatura* Project and third, the ecological and solidarity economy fairs. The various events are mostly promoted to integrate the academic or local community into the university campus and are related to camps, picnics, scavenger hunts, trails and activities that do not fit into the previous classifications.

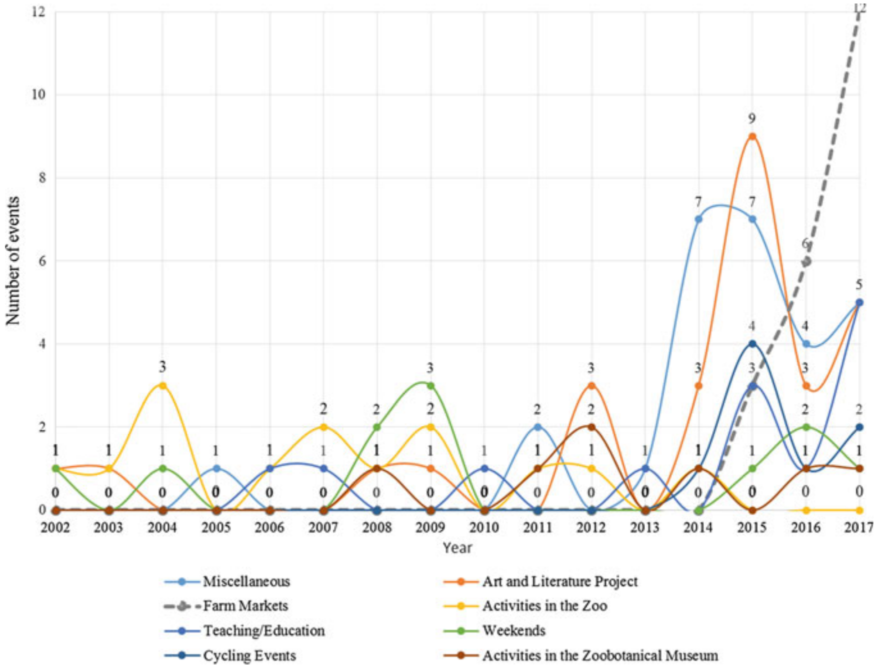

Fig. 6 Events' evolution by thematic

Table 7 Events classification by thematic

Thematic	Percentage (%)
Miscellaneous	22
Art and literature project	20
Farm markets	16
Activities in the zoo	11
Teaching/Education	10
Weekends	9
Cycling events	6
Activities in the Zoobotanical Museum	6

Events related to the *Arte & Literatura* Project also focus on the local community, specifically children. In this theme, ludic activities are promoted about literary works in the spaces of the campus.

Last but not least are the Farm Markets, that are ecological and solidarity economy fairs that are currently promoted by the institution twice a month and bring to the campus and local community organic food options cultivated by local farmers as well as handicrafts that promote sustainable and conscious consumption. These events were so successful that the University intends to increase their frequency in 2018.

Table 8 Sustainable practices in green areas on campus

University	Abbreviation	Practice description
University of British Columbia	UBC	UBC Farm, fresh organic produce
Brown University	BU	Brown student garden project to produce salad mix, tomatoes, basil, zucchini, cucumber, eggplant
University of Georgia	UG	Arbor program, planting trees around the campus and practicing sustainable landscaping
University of Minnesota	UM	Cornercopia Student Organic Farm, participation of students in the production of food organically in the student farm
University of Pennsylvania	UP	GreenFund Garden project, an on-campus garden project started by students and funded by the administration

Source Sustainable Endowments Institute (2011b)

4.3 *Good Practices in American and Canadian HEIs and the Possibility for UPF*

The survey based on the Green Report Card showed that 141 out of the 322 analysed institutions (44% of the total) have actions aimed at optimizing the green areas of their campuses. Table 8 describes practices adopted by 5 out of 52 institutions recognized as *Overall College Sustainability Leaders*, schools that achieved the best grades across all categories.

Among these actions, four of them must be highlighted: the implementation and maintenance of gardens on campus, mostly with the aim of providing organic food to the institutional dining rooms, which was pointed out as the most recurrent (59% of the time); the activities directed to the maintenance of farms in the campuses, also with the purpose of providing organic food to the institutions with 26% of occurrence; the creation of gardens with access to the local community—community gardens, with 23% occurrence and last, with 8% occurrence, actions promoting the planting of trees on the campuses of the institutions. In this sense, all these actions can be incorporated into the University of Passo Fundo.

These activities, in addition to encouraging the consumption of organic food and thus contributing to the promotion of sustainable livelihoods, ensure that soil management is done properly. Allied to this is the fact that, most of the time, activities are carried out by the students, making it clear that sustainability education (SDG 4) is practiced in a practical way and together with the sustainable management of terrestrial ecosystems (SDG 15) and in this way the interaction between the two SDGs is consolidated. With these examples, suggestions of good practices can be made, adapting to the local reality of the UPF main campus.

Table 9 Sustainable practices in green areas on campus

4 QUALITY EDUCATION	– Promotion of teaching and learning through classes and activities taking advantage of the green areas – Promotion of community appreciation as a result of sports and leisure activities – Informal and non-formal learning opportunities through outreach activities, connecting HEI and the local community
15 LIFE ON LAND	– Promotion of farm markets to encourage sustainable and organic agriculture – Incentive to students' organic farm or gardening projects inside university campus – Development of arbor programs, which can promote biodiversity and contribute to green areas conservation and preservation

Table 9 summarizes and highlights the role that green areas in university campuses play in the promotion of SDGs 4 and 15, considering the case study made and the research for good practices.

5 Conclusions

Knowing the opinion of the academic community integrates the importance of SDGs in society, in this case SDG 4 and SGD 15. Therefore, promoting environmental education by encouraging the use and care of green areas of the campus should be a management action, through the development of sustainable projects with social actions, which have the function of interacting the faculty and students of the campus, as well as the employees, that is, the whole community that attends daily the green areas of the campus needs to learn from them and respect them.

The interaction between SDGs 4 and 15 on a university campus is not only achieved by the presence of a preserved and wooded space, but also when the green infrastructure of these spaces is worked in order to bring sustainability into the campus. Thus, the respondents of the questionnaire emphasized the need to identify the tree species present on campus, a practice that stimulates the sustainable management of these ecosystems and facilitates the environmental experiences that promote education for sustainability.

The events promoted on a university campus can also contribute to people's awareness and sustainable posture. This is because, through ecological fairs, the local reality is worked out in connection with planetary reality, since these events promote education for sustainability insofar as they stimulate and strengthen agriculture and sustainable consumption. Along with this, the proper management of the green areas of UPF's main campus has ensured that many species threatened with extinction or that have been commercially exploited for years are protected. Also, the Green Report Card search for good and successful practices in the green spaces of university campuses has shown that other actions can be applied at the UPF main campus.

According to the research carried out by US and Canadian universities, with the purpose of suggesting similar practices to UPF for the application on the campus, since even if the institution is not considered sustainable, it has a great ecological potential, with extensive presence of green spaces, which can be well used.

This case study can confirm the potential of Higher Education Institutions in local promotion of sustainable development goals, especially through the well-articulated management of their green areas. To do so, they must understand their responsibility in making the world more sustainable by incorporating the Agenda 2030 in their institutional agenda.

Appendix 1—Feedback of Undergraduate Courses

Course	Number of respondents	Feedback %
Civil Engineering	63	12.9
Architecture and Urbanism	36	7.4
Graduate Programs	32	6.5
Law	23	4.7
Chemistry	21	4.3
Veterinary Medicine	21	4.3
Agronomy	18	3.7
History	17	3.5
Journalism	17	3.5
Mechanical Engineering	16	3.3
Production Engineering	15	3.1
Education	14	2.9
Languages and Literature	14	2.9
Chemistry Engineering	13	2.7
Environmental Engineering	13	2.7
Advertising	12	2.5
Psychology	12	2.5
Electrical Engineering	10	2.0
Biological Science	9	1.8
Physics	9	1.8
Computer Science	8	1.6
Visual Arts	8	1.6

(continued)

(continued)

Course	Number of respondents	Feedback %
Business	7	1.4
Food Engineering	7	1.4
Pharmacy	7	1.4
Mathematics	6	1.2
Graphic Design	5	1.0
Medicine	5	1.0
Music	5	1.0
Physical Education	5	1.0
Analysis and System Development	4	0.8
Dentistry	4	0.8
Nursing	4	0.8
Nutrition	4	0.8
Physiotherapy	4	0.8
Accounting	3	0.6
No classification	3	0.6
Agribusiness	2	0.4
Economic Science	2	0.4
Computer Engineering	2	0.4
Mechanical Production Engineering	2	0.4
Aesthetics and Cosmetic	1	0.2
Commercial Management	1	0.2
Geography	1	0.2
Human Resource Management	1	0.2
Mechanical Manufacture	1	0.2
Social Work	1	0.2
Speech Therapy	1	0.2
Fashion Design	0	0.0
International Commerce	0	0.0
Internet Systems	0	0.0
Logistics	0	0.0
Philosophy	0	0.0
Product Design	0	0.0
Secretarial Studies	0	0.0
Total	489	100

Appendix 2—Feedback of Employees by Unit Academic

Academic unit	Number of respondents	Feedback %
Institute of Biological Sciences	24	8.6
Institute of Exact Sciences and Geosciences	13	4.7
Institute of Philosophy and Human Sciences	26	9.3
Faculty of Arts and Communication	13	4.7
Faculty of Agronomy and Veterinary Medicine	22	7.9
Faculty of Education	3	1.1
Faculty of Physical Education and Physiotherapy	2	0.7
Law School	6	2.2
Faculty of Economics Sciences, Administration and Accounting	10	3.6
Faculty of Engineering and Architecture	35	12.5
Faculty of Medicine	2	0.7
Faculty of Dentistry	4	1.4
Rectory/Administrative	63	22.6
Marketing and Communication Agency	7	2.5
Central Library	5	1.8
High School Center Integrado	7	2.5
Vigilance	1	0.4
UPF Languages	1	0.7
Technological Park	5	1.8
No classification	29	10.4
Total	279	100.0

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How Do You Teach Undergraduate University Students to Contribute to UN SDGs 2030?

Eric Pallant, Beth Choate and Benjamin Haywood

Abstract The 17 UN Sustainable Development Goals (SDGs) are designed to mobilize countries around the world to end all forms of poverty, fight inequalities and tackle climate change, while ensuring that no one is left behind. Institutions of higher learning are important actors in creating individuals with the skills to accomplish these goals. The Environmental Science and Sustainability (ESS) Department at Allegheny College (Meadville, PA) has been working for 40 years to produce students capable of solving real-world environmental problems by teaching students to think critically and communicate science. This review involved a comprehensive analysis of existing classes at Allegheny College with a focus on the alignment of SDG principles with learning outcomes for core courses required of all students majoring in ESS. The ESS curriculum implicitly supports the goals of the UN SDGs by using local, state and international environmental issues to demonstrate the realities of considering both the environment and well-being to advance a more sustainable and equitable future. The aim of this paper is to highlight how a university curriculum might explicitly focus on the principles of the UN SDGs. In discussing this model, this paper identifies essential components and potential gaps in university curricula and offers one template to provide a more thorough approach to educating for the SDGs.

Keywords Education for sustainable development · United Nations · Sustainable development goals

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1 Introduction

In September 2015 the United Nations (UN) launched its Sustainable Development Goals (SDGs) addressing climate change, renewable energy, food, health, water quality, equity and social justice (http://www.un.org/sustainabledevelopment/sustainable-development-goals/). The 17 SDGs contain 169 targets, many of which are still waiting for more specific definitions (Lu et al. 2015.) The SDGs succeed the Millennium Development Goals (MDGs) as reference goals for the international community for the period of 2015–2030 (UN 2015) and more intentionally recognize the relationships between people and the planet. These aspirational goals represent a significant step forward from the Millennium Development Goals because they are an integrated network of interconnected targets that are designed to guide both developed and developing nations (LeBlanc 2015). Measuring success of UN SDGs will require new concepts and metrics related to indicators at the national level (Constanza et al. 2016; Hák et al. 2016).

For the last decade, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) has helped coordinate Education for Sustainable Development (ESD) (UNESCO 2014). UNESCO is also working with several additional UN groups (UN Department of Economic and Social Affairs, UN Global Compact's Principles for Responsible Management Education (PRME) initiative, UN University (UNU), UN-HABITAT and UNCTAD) to develop the Higher Education Sustainability Initiative (HESI). The objective of this initiative is to provide a platform for colleges and universities to engage with the UN SDGs and over 300 institutions have now joined (https://sustainabledevelopment.un.org/sdinaction/hesi). Education was identified as a standalone goal of the UN SDGs (SDG 4) and many of the targets for that goal require universities to act, while others relate directly to learning and teaching (SDSN Australia/Pacific 2017). However, the extent to which education is integrated across all 17 goals is variable (Vladimirova and LeBlanc 2016).

Education for Sustainable Development (ESD) can help move the concept of SDGs beyond UN terminology and into practice. Even still, the educational community has struggled to embrace the broader concept of sustainable development (Venkataraman 2009). Wals (2011) has cautioned that ESD runs the risk of overemphasizing "correct" and "incorrect" behaviors, which could result in big-brother sustainability or eco-totalitarianism, instead of focusing on ways of thinking and problem solving.

Vare and Scott (2007) suggest two primary components of ESD, recognizing the need for an emphasis both on content and process-based skills and competencies. The first component is built around traditional forms of education during which recipients receive information about which options are more sustainable and why. The recipient is then assumed to make rational decisions that promote more sustainable behaviors. But, Vare and Scott point out that people rarely change their behaviors in response to a rational call to do so. Thus, they recommend a second ESD component based on building capacity to think critically about what experts say and to test ideas, exploring the dilemmas and contradictions inherent in sustainable living. The significance of this second component is echoed by Sterling (2010) who states that an educational focus on critical thinking, capacity building, and resiliency in the face of future uncertainty, threat, and surprise creates individuals who can best respond to the needs of sustainable development efforts.

Other scholars have noted that ESD must contain opportunities for social learning through the interrogation of values, norms, and beliefs as these are often neglected in ESD curriculum and yet undergird every aspect of sustainable development (Wals 2007). As such, ESD practices designed in a culturally sensitive framework are often the most nimble and effective at aligning with local and regional values and norms (Savelyeva and Douglas 2017). Further still, even if knowledge and attitudes change due to educational interactions, Arbuthnott (2009) contends that university students need opportunities that help them find ways to *influence* social norms and practice and to act in ways consistent with their beliefs.

As a whole, research on ESD highlights several important tenets of the practice as noted above (reviewed extensively in Wiek et al. 2011). These include a focus on the rational examination of relevant information; emphasis on the development of critical thinking skills; applied experimentation where students are forced to negotiate inherent tensions between economic, environmental and social dimensions of SD and align beliefs with practice; space to wrestle with the values and norms that drive and shape social, economic, and political decisions; and the cultivation of flexible and adaptive practices to support resiliency.

Such tenets align well with the mission of the liberal arts model of higher education. The term “liberal arts” is used mainly by United States (US) institutions that offer a smaller student body and class sizes, smaller faculty-to-student ratios, faculty that focus primarily on teaching undergraduate students, and a wide-ranging curriculum designed for breadth and holistic integration. The aim of a liberal arts education as stated by Gerald Greenberg is to teach students “to think critically, communicate clearly, analyze and solve complex problems, appreciate others, understand the physical world and be prepared to learn continuously so they can work with others and on their own to meet the challenges of the future” (Strauss 2015). Students are often trained to solve complex, real-world problems both independently and in groups (Ensign 2017). Graduates with a liberal arts education are well prepared to problem solve and tackle a plethora of challenges that come with executing the UN SDGs. Ensign (2017) argues that universities and colleges are responsible for producing students with both traditional degrees, but also the ability to act as agents of change throughout the world. These individuals will graduate and enter society as part of “the energetic society” that is required to ensure that sustainable development goals become reality (Hajer et al. 2015).

Unfortunately, in recent years, the term “liberal arts” in the U.S. has become associated with institutions serving a political agenda while the focus on breadth of education and integration of concepts and disciplines has been questioned by those advocating a more skill- or discipline-focused education (Strauss 2015). In a time when the liberal arts needs a champion and creative re-branding, the UN SDGs provide a unique opportunity. Demonstrating how liberal arts institutions prepare students to meet the needs of the world, as determined by the United Nations, is a unique way to demonstrate the practicality and necessity of liberal arts college graduates. The goal of this paper is to demonstrate how the existing Environmental Science and Sustainability (ESS) curriculum at Allegheny College (Meadville, PA) aligns with the UN SDGs to create graduates that are well positioned to act as "extension agents" to the world (Ensign 2017).

The preparation of this paper involved a comprehensive review of existing classes in the Environmental Science and Sustainability major at Allegheny College with a focus on the alignment of learning outcomes for core courses required of all students majoring in ESS with central SDG principles. Only those SDG goals that had direct links to the learning outcomes of a specific course were "tagged" for that course. Faculty teaching core courses were then interviewed to elicit exemplary class foci, units, and exercises that could serve as best practices for infusing UN SDGs into a curriculum for undergraduate ESS majors.

2 The Core Curriculum in Environmental Science and Sustainability

All Environmental Science and Sustainability majors are required to take five core courses, ESS 110, ESS 201 & 210, ESS 585, ESS 600/610 (see descriptions below). Each of these courses infuses the UN SDGs into the curriculum through targeted content, assignments, readings, and projects. These core courses are discussed below and examples of the inclusion of the UN SDGs are provided. In addition to these five courses, ESS majors take additional foundational courses to ensure basic skills in natural and social sciences, as well as a cohort of courses (area of specialization) that allows them to gain depth in one of the five central themes of the UN SDGs—people, planet, prosperity, peace, or partnerships.

3 Year 1. ESS 110. Introduction to Sustainability—"Think Sustainability"

The Introduction to Sustainability course forefronts the synthesis of the three major pillars of sustainable development: people, planet, and prosperity. The goal is to demonstrate for students how the interaction of these three main pillars lead to the 17 UN SDGs. This approach of highlighting synthesis of pillars of sustainability is educationally the opposite of presenting silos of knowledge—ecology, politics, energy, population, climate change—and then expecting students to make the connections on their own. As one example—during the teaching of food and fiber, students are asked to investigate the life cycle analysis of a food item. Students have to do research on the environmental impacts of a food product, as well as the economic and social impacts of food production on global food growers and laborers, processors, manufacturers, transporters, servers, preparers, and waste haulers. A well-done homework assignment will require students to understand that food production of even a single ingredient requires understanding the interplay of sustainable development goals 1, 2, 3, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, and 16. Exercises like this are designed to train students to think in an integrated and synthetic framework ("think sustainability"). They become critical thinkers and learn to apply a holistic approach to any consumable product or energy choice from cradle to grave with equal attention to issues brought to light by the UN SDGs: equity, gender, climate change, life on land, etc.

4 Year 2. ESS 201. Environmental Problem Analysis—"Analyze Sustainability"

Following exposure to the breadth of the UN SDGs in the introductory course, students enroll in ESS 201 whereby they begin to utilize the integrated thinking developed in ESS 110 to engage in analysis of contemporary environmental problems. This course recognizes that the first step in tackling any complex, global challenge involves a detailed analysis of the issue at hand in order to understand the often compounding causes, impacted systems, and interests involved. Students learn how to find and evaluate robust information, question and interrogate taken-for-granted assumptions and ideas, and integrate diverse perspectives in order to conduct a comprehensive analysis of three "wicked" environmental problems (Balint et al. 2011). As students develop skills around the evaluation of information sources and the effective communication of research, they are tasked with the interrogation of the root causes, social and political influences, ecological contexts, and confounding variables that surround issues of focus.

Of central importance in this course is the idea that no environmental problem can be analyzed fully in a siloed fashion, and that effective solutions to these problems are only possible once a comprehensive analysis that has considered all three pillars of sustainability is complete. Not only must one think sustainably, but they must be able to gather and interpret information from natural science, social science, and the humanities in order to grasp the intricacies that surround sustainable development problems. The last third of this class is designed by student participants who are responsible for selecting a wicked environmental challenge, constructing an outline of the dimensions of the problems, procuring information sources, and facilitating the discussion and activities around such analysis. As each student develops a proposal for this final unit, they must demonstrate how their proposal provides adequate opportunity to explore the proposed topics through the lens of each central sustainability pillar. One recent topic selected focused on the problem of unsustainable urban growth and the need for sustainable cities, requiring students to analyze limits to ecological capacity, social institutions and structures of power and injustice, and macro-economic systems that might incentivize renewable technologies.

Table 1 The UN sustainable development goals that were discussed during ESS 201: environmental problem analysis unit on urban growth and sustainable cities

1 NO POVERTY	*How could "green" gentrification be prevented and equal environmental benefits and risks be ensured?*
3 GOOD HEALTH AND WELL-BEING	*Emissions associated with urban environments often have public health implications. Could those be limited by switching to renewable materials, fuels, or more trees?*
4 QUALITY EDUCATION	*Education is linked to livelihoods and livelihoods to opportunities to enjoy environmental benefits in urban environments and escape from cycles of chronic risk exposure.*
6 CLEAN WATER AND SANITATION	*Exploration of strategies used in large urban areas (NYC, for example) to preserve the ecosystems that maintain clean water and bioremediation technologies that neutralize human waste. Is this possible everywhere?*
7 AFFORDABLE AND CLEAN ENERGY	*How could the infrastructure and residential and industrial systems of urban environments be used to produce renewable energy sources (could buildings, homes, or everyday activities (climbing the stairs) generate clean electricity?)?*
8 DECENT WORK AND ECONOMIC GROWTH	*What new economies are emerging in urban environments that are not based on the extraction of raw materials and the production of wastes?*
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	*What kinds of cyclic production systems might be possible?*
10 REDUCED INEQUALITIES	*The issue of institutional racism provided a window through which to consider how political and economic systems may perpetuate inequalities and what might change such practices.*
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	*What is this zero waste craze and could it work in an urban environment?*
13 CLIMATE ACTION	*What local-level policies or actions actually make a difference in reducing emissions? How might cities become more flexible for future adaptation needs?*
15 LIFE ON LAND	*How might urban centers make room for other species? What planning mechanisms best preserve healthy terrestrial ecosystems around urban centers?*

This project, although centrally focused on SDG 11, directly investigated issues related to eleven additional goals (see Table 1).

5 Year 2. ESS 210. Environmental Research Methods.—"Research Sustainability"

ESS 210 introduces students to the research process and environmental problem-solving methods. Students investigate real-world problems using quantitative, qualitative, social science, and natural science methods. Research examples are placed inside social, cultural, political and economic contexts, not just as objects of scientific investigation. For instance, students in one section of ESS 210 were asked to assess the use of bottled water on Allegheny's campus (Choate et al. 2018). Observation of students on campus indicated that plastic bottled water is extremely prevalent on campus, with many students purchasing cases of water at a time. When presented with the embodied energy and virtual water consumption of a plastic bottle, students first suggested a campus disposable bottled water ban and removing all plastic, disposable water bottles from campus.

The class research project encompassed analysis of who on campus is consuming bottled water, where they are purchasing the water, what is their preferred type of drinking water and why, as well as additional questions about reusable bottle ownership and usage. The research identified that disposable bottled water was most commonly consumed by first year students, with rates of use decreasing the longer students are on campus. It was speculated that this decreasing use over time may reflect new students learning the "sustainable expectations" of Allegheny College, while for others, their parents may have initially purchased the bottled water but they have not continued to do so now that they are 3rd and 4th year students. Many students were unsure if local tap water was a safe drinking source, while others did not like the taste and the fact that it was different from their home. And many students preferred bottled water due to convenience. The students also learned that a large majority of bottled water is being purchased off campus and being brought on campus, thus a bottled water ban would do little to reduce consumption on campus. Students were forced to consider how to incite behavioral changes, the economics of bottled water, and the environmental implications of disposable bottles to develop a solution.

As a result of this study, Allegheny College has increased the number of filtered, bottle refill stations throughout campus and provides a high-quality, metal water bottle to all students upon beginning their first year. Students are also provided information about the safety of local tap water, as well as the environmental and social benefits of choosing tap over bottled water.

This project directly investigated issues related to 7 of the 17 SDGs (see Table 2).

Table 2 The UN sustainable development goals that were discussed during ESS 210: environmental research methods project focused on reducing disposable bottled water use on the college campus

3 GOOD HEALTH AND WELL-BEING	*Perceptions about the safety of bottled water versus tap water. What is better for you?*
6 CLEAN WATER AND SANITATION	*Exploration of what constitutes clean, what those standards should be, and how this is different in different places.*
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	*How might industrial processes incentivize reusable water containers?*
10 REDUCED INEQUALITIES	*Bottled water often constitutes a higher percentage of the income of impoverished households because they lack clean water. Yet, what is a luxury for the wealthy, helps create the pollution that makes this problem worse.*
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	*Bottled water companies are the worst at greenwashing the sustainability of their product. How could this be combatted?*
14 LIFE BELOW WATER	*Much of the plastic from bottled water ends up in the oceans, impacting marine life. Can it be cleaned up? What are the long-term impacts of this?*
15 LIFE ON LAND	*The impact of bottled water on terrestrial systems ranges from the emissions associated with the energy needed in production, to the toxic chemicals that come from production processes.*

6 Year 3. ESS 585. Junior Seminar in Sustainable Development—"Apply Sustainability"

In their third year of study, students must enroll in a Junior Seminar in Sustainable Development. For the full semester (15 weeks), students are tasked with designing a solution to a single problem in a way that promotes sustainability and adheres to the goals of the UN SDGs. The problem is selected by the course instructor in conjunction with a community partner and designed as a community-based research project (Lutz and Neis 2008). By the end of the semester, students will present their findings as a written report and as an oral presentation to an audience of key stakeholders. The presentation is a key element of the class as it makes clear from the outset that the research students are performing, as well as the solutions they are presenting, will be scrutinized by community members such as business leaders, directors of NGOs, other professors, university administrators, and government officials. Some recent community-based applied projects include:

- Creation of an educational space and programming in a community garden around sustainable food production and nutrition. The educational programming was divided into segments for low-income residents that used the garden and for students in grades 7–12.
- A design plan for a sustainable, educational, multi-purpose greenhouse with luminescent solar concentrators (LSC), a novel photovoltaic technology that generates electricity from "wasted" light, and a biomass heating unit. The design was instrumental in securing a grant for construction costs and the greenhouse was built within a year of the junior seminar.
- Creation of a sustainable, educational, edible hiking path for a regional middle school and high school. The path was built according to plan within a year of the junior seminar.

The UN SDGs investigated in the example of the sustainable hiking path are listed in Table 3.

7 Year 4. ESS 600/610. Senior Project (Year Long)—"Becoming an Agent of Change"

During their final year in the Environmental Science and Sustainability department, all students are required to complete a year-long independent Senior Thesis Research Project. The types of projects vary in topic and outcome, with some students' final product resembling a scientific journal article, while others may develop a business plan, or conduct a policy or literature analysis. Despite extreme variation, students are encouraged to think about their projects within a much broader framework. For example, a student that has focused much of her research on the communities of bees associated with certain flowering plants should not only be able to answer detailed questions about pollination, but also place the importance of bee and plant diversity in a larger environmental context. With the implementation of the UN SDGs as a guide for the curriculum, the department now requires all students to relate their project back to these goals. In their final product, students must identify the goals that are related to their topic and report how their project helps in accomplishing the UN SDGs. For many students, their projects will relate to a large number of the goals and understanding the global context of a small thesis project is important. Many students are only interested in stopping climate change, but seem to have little understanding as to how projects such as setting up a campus bike-share program relate to that much larger goal. The goal of requiring students to relate their projects to the UN SDGs will aid in the understanding that small, incremental movements in the right direction are benefitting the larger aims of the United Nations.

An example of a Senior Thesis Project that encompassed several of the UN SDGs focused on developing a climate adaptation plan for fairtrade vanilla growers in Uganda (Kelley 2016). The student analyzed existing literature to determine what factors will influence smallholder vanilla farmers' decisions in adapting to

Table 3 The UN sustainable development goals that were discussed during ESS 585: junior seminar on sustainable development project focused on conducting community-based projects

2 ZERO HUNGER	*The path was lined with berry bushes and fruit trees designed to produce edible snacks for visitors and programs were implemented to encourage public use.*
3 GOOD HEALTH AND WELL-BEING	*The path was integrated with boulders for climbing, beams for balancing on, outdoor musical instruments, and other means of increasing exercise and interactions with the outdoors.*
4 QUALITY EDUCATION	*Educational signage was developed along the path explaining the selection of particular plants and the selection of certain path materials as that relates to sustainable practice.*
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	*The materials selected for benches, signs, interactive exercise features, and path materials were chosen on the basis of Life Cycle Analyses to determine least impact on the environment.*
10 REDUCED INEQUALITIES	*The path leads from the region's largest middle school to an educational garden and serves a student population with very high poverty rates. Many students do not have regular access to high quality foods or play areas in nature.*
11 SUSTAINABLE CITIES AND COMMUNITIES	*The path beautified a previously open field adjacent to a parking lot. The installation of native grasses, vegetables, flowers, fruit trees, boulders, and benches created a park-like environment for use by the public.*
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	*The path encourages exercise in nature, consumption of freshly harvested fruits and spices, and production of useful vegetables and fruits.*
15 LIFE ON LAND	*In addition to plants to serve humans with edibles, the path also is lined with plants that appeal to native pollinators and birds.*
17 PARTNERSHIPS FOR THE GOALS	*Students in the junior seminar partnered with the regional school district, the regional recreation facility, area contractors, and the Community Wellness Initiative (Hinton et al. 2017).*

climate change and drought. The student found that factors such as age, gender, agro-ecological zone, traditional knowledge, access to meteorological reports, and government/extension services were major influences of adaptation. The final product included a corporate fact sheet entitled "Supporting Ugandan Vanilla Suppliers As They Adapt to Drought" to be given to corporations sourcing vanilla from these farmers such as Ben and Jerry's. The fact sheet provided information on how to best assist these farmers in adapting to drought conditions when considering the factors above. A second fact sheet was created with farmers as the audience and provided information as to how farmers might adapt to changing climates. This project integrated 13 of the 17 SDGs as shown in Table 4.

Table 4 The UN sustainable development goals that were discussed during ESS 600 & 610: senior project aimed at developing a climate adaptation plan for vanilla farmers in Uganda

1 NO POVERTY	*The project was focused on ensuring that small farmers can continue a productive business despite impending changes in climate and weather patterns.*
2 ZERO HUNGER	*While the consumption of vanilla may not prevent individuals from going hungry, for those farmers that rely on the farming of vanilla for their income, it is likely that this project could aid in feeding their families.*
3 GOOD HEALTH AND WELL-BEING	*Finding low impact methods of adapting to climate change are important for the well -being of farmers and others living in the community.*
4 QUALITY EDUCATION	*The project focused on assisting farmers in finding ways to adapt to changes in water abundance, as well as educating the corporations that purchase the vanilla about how they can best assist the farmers within their network.*
5 GENDER EQUALITY	*The student found that both men and women are often responsible for planting and caring for crops, while women are also responsible for caring for the household and children. Combined with the likelihood that women have received less education than men, they are less likely to have the time and energy to be concerned about drought adaptation.*
8 DECENT WORK AND ECONOMIC GROWTH	*Ensuring that these farmers continue to have work and a way to make a living was the underlying theme of the entire project.*
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	*This project was extremely innovative in the way in which suggested adaptations were carefully planned and explained to farmers and corporations.*
10 REDUCED INEQUALITIES	*Reducing inequalities between farmers in developed nations that may have extensive resources and those in developing nations was a key theme of this project.*
11 SUSTAINABLE CITIES AND COMMUNITIES	*The project focused on creating communities that can sustain themselves throughout a constantly changing climate with extreme rainfall and droughts.*
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	*The project was designed to assist Ben & Jerry's in aiding their fair trade vanilla farmers. This is the perfect example of creating a product that consumers can feel good about.*
13 CLIMATE ACTION	*Again, the theme of the project was to assist farmers in taking action in adapting to climate change.*
15 LIFE ON LAND	*The project focused on sustainable use of the land to provide for farmers, but also conserve ecosystems.*
17 PARTNERSHIPS FOR THE GOALS	*This project was a partnership between the Allegheny College Environmental Science Department, Ben & Jerry's ice cream, and Ugandan vanilla farmers. Such connections are essential to move forward with the UN SDGs and seek to create a truly sustainable world.*

8 Area of Specialization

Although the curriculum ensures that every graduate experiences a scaffolded and integrated core curriculum to move students from thinking, analyzing, and researching to applying sustainability within a UN SDG framework, students must also engage with a more concentrated area of study that allows the student to explore personal interests and passions and obtain sufficient depth of knowledge within that area of focus. As such, ESS majors are required, in consultation with their major advisor, to developed and complete a cohort of courses (seven total) that revolve around a core area of specialization. Students are asked to relate that focus area back to one of the five central themes of the UN SDGs—people, planet, prosperity, peace, or partnerships.

A student interested in a theme around prosperity, for example, might design a plan of study that includes courses like Ecological Economics; Nonprofit Management and Social Entrepreneurship; and the Economics of Entrepreneurship, while someone interested in a theme around peace could elect to enroll in courses like Ethics and Community; Power, Society and Social Change; Oppression and Liberation; and Global Justice. Each of these courses is offered in a department outside of ESS. A host of opportunities exist for students to focus on a defined topic within the five central UN SDG themes, allowing students the flexibility and freedom to broaden understanding and apply the knowledge acquired in the classroom to the challenges of the twenty-first century. The specific courses and theme concentrations offered at Allegheny are not as important as the fact that the curriculum grants attention both to breadth and depth, with equal emphasis on obtaining the skills necessary to engage with the UN SDGs in everyday life and the requisite knowledge within a specialized area of interest to adequately and carefully craft intelligent solutions.

9 Co-curricular Experiences

Recognizing the value of co-curricular educational experiences (Stirling and Kerr 2015), ESS expects all students will engage in an experience beyond the classroom for the purpose of understanding the challenges involved in translating the theoretical underpinnings and lofty goals of the UN SDGs to actual problems. Toward this end, the ESS curriculum strongly encourages students to engage in at least one co-curricular experience of applied learning. Students are advised early on to consider, in consultation with their advisor, the best mode to achieve this goal. Students may elect to engage in a paid or unpaid internship, conduct research with a faculty member through independent study, participate in a study abroad or experiential learning trip (2–3 weeks in duration) or serve as a regular volunteer in the community. Students work with their advisor to select an experience that is both challenging and motivating and to situate that opportunity within the overall UN SDG goals.

Table 5 The UN sustainable development goals covered during an ESS internship focused around food, gardening and nutrition

1 NO POVERTY	*Students in the middle school receiving the lessons taught by college students are disproportionately low income. Learning to grow their own food can provide a small relief from food expenses.*
2 ZERO HUNGER	*In fact, for many middle school students in the region, food security is a primary concern.*
3 GOOD HEALTH AND WELL-BEING	*Food lessons include teaching food preparation and the difference between nutritional foods and highly processed foods high in calories.*
4 QUALITY EDUCATION	*Allegheny students learn how much work is required to deliver quality education and the central components of quality curriculum.*
10 REDUCED INEQUALITIES	*By teaching middle students to grow and prepare their own foods, Allegheny College students involved in doing the teaching are providing greater equity in terms of who has access to fresh, local, and healthful foods.*
11 SUSTAINABLE CITIES AND COMMUNITIES	*It has been observed that when Allegheny students teach middle school students that those middle school students often change the shopping and eating preferences of their families (Martin et al., 2017).*
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	*Lesson plans include instruction in shopping for healthful, economical, and ecological food items.*
17 PARTNERSHIPS FOR THE GOALS	*Student interns partnered with the regional school district, the Community Wellness Initiative, and local farmers.*

Just one example of an ESS internship students elect is an opportunity to prepare and implement education plans for middle school students around issues of food, gardening, and nutrition. They spend several weeks working with an educator to research and develop their lesson plans and then go into classrooms to teach middle school students. As such, they engage with 8 of the UN SDGs (Table 5).

Another popular internship option is to work with the environmental education group Creek Connections. Creek Connections hires up to 16 students each year to assist in their outreach programming with local schools teaching students ages 10 through 18. Students assist in water quality monitoring, sampling invertebrates, and site surveys. Additionally, they help develop teacher resources, prepare equipment for school visits, enhance the website, and develop a newsletter. Throughout this internship the UN SDGs listed in Table 6 are addressed.

Table 6 The UN sustainable development goals covered during an ESS internship focused on environmental education and stream quality monitoring

4 QUALITY EDUCATION	*During the 2017-2018 school year, Creek Connections worked directly with 6000 students and 100,000 indirectly. Forty nine schools in 3 states were impacted by their work providing educational experiences on natural science related topics.*
5 GENDER EQUALITY	*Both men and women work for Creek Connections as interns. When those individuals go into classrooms, it works to dissolve the stigma that women are not capable of entering science fields.*
6 CLEAN WATER AND SANITATION	*Both the interns and the students they are teaching learn about water sampling and indicators of water degradation, as well as the problems with poor water quality.*
11 SUSTAINABLE CITIES AND COMMUNITIES	*The water chemical sampling and assessment of bioindicators in the water is used to determine the health of a stream. Through consistent stream testing, the program is ensuring that the water and ecosystems throughout this area are protected and sustained.*
14 LIFE BELOW WATER	*Interns learn to identify macroinvertebrates that are essential to stream quality.*
15 LIFE ON LAND	*Many educational components of the program teach students about the importance of preserving ecosystems on land, as well as below water.*

10 Connecting the Pieces

Recent structured interviews and surveys with ESS second and fourth year students indicated that there are key components necessary in helping them understand the interconnectedness between course material, real-world experiences, and the UN SDGs. Students stressed the importance of understanding the historical context of course topics to deepen knowledge of the interconnectedness of the issues as well as the importance of discussing how environmental challenges lead to the disproportionate distribution of environmental risks and benefits among diverse groups of people (environmental justice). No matter the course focus, faculty find that situating the issue within historical and contemporary socio-ecological networks helps students grasp the holistic nature of the UN SDG framework and understand how those interactions have influenced historical and contemporary events.

Even still, students indicated that despite the interdisciplinary nature of most courses, their experiences lack coherence without a structure "above" the curriculum to facilitate connections and interactions among their experiences. As such, intentional and appreciative advising (Egan 2015) is a critical component of any curriculum centered on the synergistic UN SDGs. The goal as faculty advisors is to help students build connections, identify themes, and transfer skills across their formal and informal academic experiences. This involves regular conversations about the selection of courses and content connections, the sequencing of co-curricular activities and application of knowledge outside of the classroom, and future goals and aspirations as they relate to the UN SDGs. Efforts to highlight other departments and courses at the college that complement the core curriculum and draw from the expertise of colleagues in diverse disciplines is an important part of this advising. Once students reach their fourth year, they should feel comfortable identifying how their own passions and experiences align with specific SDGs and how those connections are made through their year-long senior independent research project.

11 Successful Student Integration

While not every student that graduates with a degree in ESS applies the UN SDGs to her or his work, many graduates are uniquely qualified to understand the interconnectivity of the 17 goals. One example is Mirno who, following graduation, has worked for several refugee resettlement agencies around the world. Hired at first to manage simple logistics like ensuring availability of clean water and sanitation (Goal 6), Mirno has quickly risen in positions of responsibility because of his acknowledgement that supplying clean water and sanitation are intimately tied to Good Health and Wellbeing (Goal 3), Gender Equality (Goal 5), Industry, Innovation and Infrastructure (Goal 9), Sustainable Cities and Communities (Goal 11), Life Below Water (Goal 14), Life on Land (Goal 15), Peace, Justice and Strong Institutions (Goal 16), and Partnerships for the Goals (Goal 17). In only a few years he has become the primary logistics and systems analyst for war refugees from Syria, Iraq, Myanmar, and the Congo in camps with tens of thousands of inhabitants.

At a more local level, another recent graduate Taylor has applied the UN SDGs to issues of food security in rural America. She teaches low-income students in schools how to grow, purchase, and cook with wholesome foods. Her curricula address: No Poverty (Goal 1), Zero Hunger (Goal 2), Good Health and Well-Being (Goal 3), Quality Education (Goal 4), Reduced Inequalities (Goal 10), Sustainable Cities and Communities (Goal 11), Responsible Consumption and Production (Goal 12), and Partnerships for the Goals (Goal 17).

12 Conclusions

Application of the UN SDGs to Allegheny College's ESS has produced graduates with the comprehension that promoting sustainable development requires the integration of the UN SDGs. This is achieved via a curriculum that moves students through a process of thinking, analyzing, researching, and applying components of all 17 SDGs to local through global challenges, providing both a scaffolded core set of courses with the flexibility for specialized focus and depth of understanding around topics of student interest. Even still, our experience suggests that in order for students to develop clear links among the many SDGs and a comprehensive understanding of sustainable development, administrative practices must be in place to both connect these components to past context and historical events and contemporary opportunities for application. Students that receive a systematic education of the UN SDGs at the university level are then capable of implementing holistic solutions to some of the world's most vexing problems.

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Sustainable Campuses as Living Labs for Sustainable Development: An Overview of a Brazilian Community University

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Abstract The growing societal demands for higher education institutions (HEIs)' actions towards sustainable development, characterize these institutions as powerful drivers of change. Accordingly, this paper aims to understand how sustainable campuses, as living labs, promote innovations for sustainable development through the case of a Brazilian Community University. To accomplish this objective, this study presents a review of literature on sustainable development at universities, followed by the analysis of the case of a Brazilian Community University, the University of Southern Santa Catarina (Unisul). For the data collection, we performed semi structured qualitative interviews with 15 faculty members of Unisul, aligned with the review of the university's institutional documents and the categories mapped in the literature. The implementation of sustainable campuses as living labs at HEIs creates a propitious environment for innovation and practical learning, motivating both internal and external communities, leading society towards sustainable development. Thus, as a community university, Unisul promotes several practices to engage the community through education, capacity building, research, outreach, academic events, consulting on business, architectural assistance and medical consulting to the community, legal assistance, medical clinics, also promoting sustainability in campuses' infrastructure, inspiring the local communities to incorporate the university's sustainable values.

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1 Introduction

Since the 1970s, the international awareness on environmental education and further education for sustainable development (ESD) is increasing (Mckeown and Hopkins 2010; Lozano et al. 2015b). In 1975, the United Nations Educational, Scientific and Cultural Organization (UNESCO) issued the Belgrade charter, stating the primary role of education in overcoming environmental challenges through capacity-building, international cooperation, and development of interdisciplinary, continuous and preventive ecological education programs (UNESCO 1975).

Several other declarations, conferences and initiatives on ESD have been issued, such as the Tbilisi Declaration, the Talloires Declaration, the United Nations' Decade of ESD, the Roadmap for implementing the global action program on ESD, the Sustainable Development Goals, among others.

In 2015, global leaders through a joint effort launched the Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development, anchored in 17 Goals to ensure global development over the next 15 years. Amidst these objectives, Goal 4 reinforces the importance of promoting inclusive and quality education universally (United Nations 2017; Owens 2017).

In this context, this paper aims to understand how sustainable campuses, as living labs, promote innovations for sustainable development through the case of a Brazilian Community University. The next section presents a brief review of the literature on higher education for sustainable development and sustainable campuses as living labs; followed by the presentation of the methods, the results and discussions of the findings, and the conclusions and recommendations.

2 Literature Review: The Role of Higher Education for Sustainable Development

The term environmental education is commonly used to emphasize the correlation between education and the awareness on environmental sustainability, developing ecological behaviors and critical thinking (Zsóka et al. 2013; Carleton-Hug and Hug 2010).

ESD is a field of research that aims to implement sustainability in the curriculum and operational activities of HEIs, leading society to adopt sustainable behaviors and thinking (Zsóka et al. 2013). ESD's goal is to encourage the establishment of new ethical and responsible mindsets, educating society towards environmental

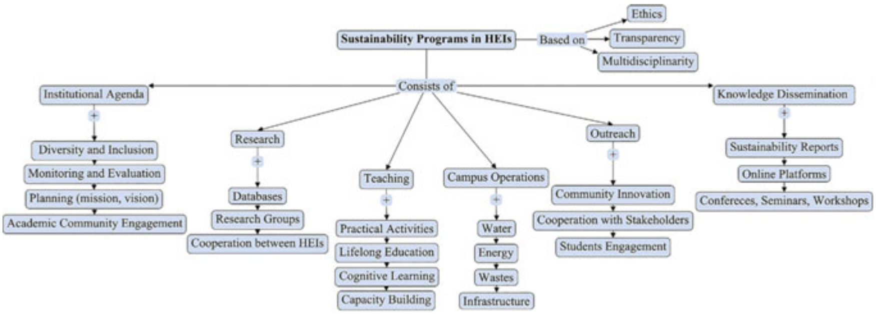

Fig. 1 Sustainability in higher education. *Source* Berchin et al. (2018)

sustainability, shaping behaviors and developing collective consciousness (Carleton-Hug and Hug 2010; Zsóka et al. 2013).

The implementation of ESD at HEIs allows the development of future leaders, ensuring that economic and social development, and sustainability can be accomplished concomitantly (Xiong et al. 2013). Therefore, several authors emphasize the importance of HEIs in the creation of an institutional agenda for sustainable development, leading society's transformation through education (Guerra et al. 2016; Berchin et al. 2017, 2018).

The creation of living labs not only contribute to sustainable development but also to the achievement of the SDGs. Actions and activities promoted on the HEIs' environment allow the collaboration between academia and the community, improving health and well-being (SDG 3), encouraging gender equality (SDG 5), promoting decent work and consequently guaranteeing economic development (SDG 8), reducing inequalities (SDG 10), promoting sustainability among cities (SDG 11), and generating innovations for sustainable development and climate change mitigation and adaptation (SDG 13).

Figure 1 summarizes several relevant actions described in the international scientific literature that can be implemented by HEIs in the development of a holistic and efficient program for ESD.

2.1 Sustainable Campuses as Living Labs for Sustainable Development

University campuses are complex environments capable of influencing both internal and external communities in its surroundings (Posner and Stuart 2013). A holistic ESD program, besides imbedding sustainability in the curricula, demands the promotion of sustainable interventions on HEIs, allowing students to experience sustainability on campus, motivating the adoption of sustainable behaviors and developing critical thinking (Azeiteiro et al. 2015; Ramos et al. 2015; Yuan and Zuo 2013).

These interventions imply intensive management and development processes within education institutions, which demand adaptation of HEIs' practices and facilities towards the implementation of sustainable initiatives (Berchin et al. 2017; Bantanur et al. 2015; Yuan and Zuo 2013).

Sustainable campus operations require the adoption of practices that stimulate energy efficiency and sustainable energy generation; sustainable transportation, such as promoting the use of bicycles, carpooling and public transportation; waste management; development of and adaptation to sustainable buildings; management of water resources; health, safety and ergonomics (Velazquez et al. 2006; Berchin et al. 2017; Bantanur et al. 2015; Waheed et al. 2011; Zhang et al. 2011; Lozano et al. 2015b; Hancock and Nuttman 2014).

Universities play a major role concerning the achievement of the SDGs, therefore, the implementation of open-innovation initiatives, such as living labs, reinforce the importance of shared knowledge among stakeholders, accelerating innovation and benefiting the society (Chesbrough et al. 2005). Living labs consist in open-innovation environments, which foster the development of sustainable solutions through a joint-effort between the university and its local communities, promoting the establishment of a collaborative, integrated and sustained system (Eriksson et al. 2005; Burbridge 2017).

Living labs consider five pillars into its core principles: value, sustainability, influence, realism and openness (Ståhlbröst 2012). Environmental innovation practices open-labs reduce the ecological impacts of economic activities, endeavoring to ensure the development of a cleaner global environment (Voytenko et al. 2016).

Experimentation is one of sustainability's essential premises and living labs act towards this purpose, turning cities and communities into research implementation fields (Dryzek 1997). Thus, living labs are crucial towards the achievement of sustainable development, especially regarding education, since the campuses' environment is propitious to promote experimentation and engagement between relevant stakeholders such as students, researchers, professors and local communities, focusing on the establishment of adequate sustainable solutions which can be locally tested, monitored, implemented and consequently solving regional or global challenges (Konig 2013).

The adoption of sustainable practices, the development of cooperative environments, outreach initiatives, water, energy and food efficient campuses constitute HEIs as relevant living labs, which contribute to society, generating shared-knowledge, integration between the community and campus members as well as solutions to local and international social, economic and environmental challenges. Table 1 shows a definition of living labs as understood in this study, also showing its main dimensions (sustainable buildings and facilities, creative and collaborative environments, collaboration and knowledge dissemination, and outreach). The adoption of these dimensions by HEIs make them key environments for sustainable development (these dimensions also supported the development of the questionnaires and the analysis of its results).

Table 1 Living labs and its dimensions

Dimension	Living labs
Description	Sustainability principles must be adopted in academic campuses operations, acting as practical learning environments, or living laboratories, where students and professors are immersed. Thus, enabling both internal and external communities to live sustainability experiences in the university
Authors	Berchin et al. (2018), Burbridge (2017), Cosgrave et al. (2013), Evans et al. (2015), Leminen et al. (2012), Ståhlbröst (2012), Trencher et al. (2015)
	Sustainable buildings and facilities
Description	Sustainable environments, besides helping to reduce the ecological footprint of HEIs, also promote the immersion of students and professors in a sustainable environment that operates as participative, socially inclusive, economically viable and environmentally responsible laboratories. In addition, such interventions create more creative and collaborative environments, stimulating active learning, awareness and critical thinking. These interventions can be made through sustainable water management, waste management and recycling programs, sustainable energy generation and energy efficiency, sustainable transport programs, green walls, green roofs and smart buildings
Authors	Adomßent et al. (2014), Anand et al. (2015), Azeiteiro et al. (2015), Bantanur et al. (2015), Berchin et al. (2017, 2018), Gómez et al. (2015), Guerra et al. (2016), Hancock and Nuttman, (2014), Lozano et al. (2013a, b, 2015a), Ramos et al. (2015), Velazquez et al. (2006), Verhulst and Lambrechts (2015), Waheed et al. (2011), Wals (2014), Yuan and Zuo (2013), Zhang et al. (2011)
	Creative and collaborative environments
Description	HEIs can contribute to the development of creative and collaborative environments propitious to an active learning and innovations
Authors	Adomßent et al. (2014), Anand et al. (2015), Azeiteiro et al. (2015), Berchin et al. (2017, 2018), Gómez et al. (2015), Lozano et al. (2013b, 2015b), Ramos et al. (2015), Velazquez et al. (2006), Verhulst and Lambrechts (2015), Wals (2014), Yuan and Zuo (2013)
	Collaboration and knowledge dissemination
Description	Collaboration with other HEIs and stakeholders in educational institutions enables the dissemination of experiences, knowledge, methods and cases of success on sustainable practices, also disseminating sustainability awareness and education
Authors	Adomßent et al. (2014), Anand et al. (2015), Azeiteiro et al. (2015), Berchin et al. (2018), Gómez et al. (2015), Guerra et al. (2016), Hancock and Nuttman (2014), Lozano et al. (2013b, 2015b), Stephens and Graham (2010), Velazquez et al. (2006), Verhulst and Lambrechts (2015), Waheed et al. (2011), Wals (2014), Yuan and Zuo (2013)
	Outreach
Description	Outreach programs, focused on ESD, stimulate students and professors to practice the knowledge teached in class, promoting local development, sustainability awareness, capacity building and engaging stakeholders
Authors	Azeiteiro et al. (2015), Berchin et al. (2018), Lambrechts et al. (2013), Lozano et al. (2013a, b), Waheed et al. (2011), Wals (2014), Guerra et al. (2016)

3 Methods

This study uses a qualitative approach to collect and analyze the necessary data to achieve its goal, "to understand how sustainable campuses, as living labs, promote innovations for sustainable development through the case of a Brazilian Community University". The University of Southern Santa Catarina (Unisul) was chosen as a case study. Unisul is a community university in South Brazil, which demonstrates its commitment with sustainability and social development.

Unisul was founded in 1964, in the state of Santa Catarina, in South Brazil. Currently, the university has nearly 30 thousand students and thousands of faculty and staffs, which collaborates to establish the relevance of its actions towards sustainable development in the communities where the university operates (Unisul 2015).

As a community university, Unisul is a non-profit institution with social responsibility, devoted to public use and committed to education, social welfare and student development (Unisul 2015; Teixeira 1994). Thus, sustainable development is a core value amidst Unisul's institutional objectives, aiming to stimulate economic development coupled with environmental preservation, social justice, sustainability and innovation. Moreover, in order to promote quality education, research and innovation, Unisul upholds a network of national and international partnerships with stakeholders and other relevant global HEIs (Unisul 2015; Berchin et al. 2018).

This study used the semi-structured interviews method to collect the data. In order to be representative, 15 collaborators were interviewed, including: the Unisul's Dean; the Pro-rector of Teaching, Research, Graduation, Outreach and Innovation; all the campuses administrations; HEIs managers on Education, Research, Outreach and Innovation, responsible for the Environmental Education Policy of Unisul, and other employees indicated by them. The Interviewees were coded from Interviewee 1 to Interviewee 15.

The open-ended questions of the questionnaire (Table 2) were based on the literature. The categories used for creating and organizing the interviews were: teaching, research, outreach, campus operations and management (Berchin et al. 2018; Guerra et al. 2016).

To analyze the data from the semi-structured interviews, we followed the indications of Bardin (2011), which are pre-analysis, when the interviews are transcribed and reviewed; material exploration, when an in-depth analysis of the collected material takes place; and subjective interpretation of the research outcomes, through the analysis and comparison among the propositions stated on the current scientific literature.

Based on the literature, the categories used for organizing and analyzing the interviews were: teaching, research, outreach, campus operations and management. Thus, after analyzing the interviews, and for the aims of this study, we organized Unisul's practices as livings labs for sustainable development according to the categories mapped in the literature: sustainable buildings and facilities, creative and collaborative environments, collaboration and knowledge dissemination, and outreach.

Table 2 Interview questionnaire

What does sustainable development mean to you?
In your opinion, what is the role of HEIs for sustainable development?
In your opinion, how do HEIs influence the development of its surrounding communities?
Regarding the development and implementation of sustainable practices at Unisul, what were the main challenges/obstacles faced?
Regarding the development and implementation of sustainable practices at Unisul, what were the main incentives/facilitators encountered? Which factors stimulated this process?
In your opinion, what is the importance of implementing sustainable practices on campuses in HEIs? How does Unisul address this issue?
In your opinion, how does Unisul promotes innovations that contribute to local sustainable development?
Which are the key-programs and actions towards sustainability implemented in the Unisul?

4 Results and Discussion: The Case of Unisul

Unisul's environmental education policies are funded on Brazilian laws regarding ESD. Even though there is an integration between Unisul's campuses and its guidelines towards ESD, each campus have the flexibility to develop its own sustainability initiatives, promoting the transversality of sustainability across the institution (Unisul 2017). Accordingly, Unisul's policies for ESD regards education, research, outreach, campus operations and management activities.

It is noteworthy that Unisul and the interviewees use the term "environmental education", but considering the literature and for the aim of this paper, we will standardize Unisul's practices as ESD. Thus, the term "living lab" was only used by one interviewee, however, we analyzed the interviews categorizing them in the dimensions of living labs, namely: sustainable buildings and facilities, creative and collaborative environments, collaboration and knowledge dissemination, and outreach.

4.1 Unisul's Practices as Living Labs for Sustainable Development

The analysis of the interviews, suggest that the implementation of sustainability practices in universities, can translate into holistic ESD programs (or environmental education programs), since universities and their campuses serve as role models of learning, awareness and inspiration for both the internal/academic community and the external community in the university's surroundings.

It is important to emphasize that among the main drivers of sustainability practices at Unisul, are: (a) normative/legal push; (b) demand from civil society; (c) internal research and outreach initiatives; (d) The community nature of the university; and e) the support of managers.

According to the interviewees 1, 3 and 13, Unisul operates as a living lab, incorporating innovative and sustainable practices in its campuses, in its research practices, outreach programs and learning methods and environment, aiming to stimulate students' development and qualification, as well as promoting the development of local communities.

Interviewee 3 also stated that Unisul acts as a community actor, by promoting a continuous dialogue with society, "either through outreach or through Unisul's concerns that its applied researches benefits the society". These practices occur through Unisul's concerns with the accessibility and inclusiveness of its actions for local development, by offering scholarships, capacitation and training programs, community service through health support centers, legal and business consulting; in addition to practices of internal sustainability, such as energy efficiency and solar energy generation that can inspire changes in the surrounding communities' behavior (Interviewees 3 and 8). Thus, Unisul is also concerned with entrepreneurship and technological and social innovation for sustainable development (Interviewee 3).

Considering the influence of university campuses in disseminating awareness and ESD, Interviewee 1 understands that

> today only in undergraduate courses we have more than 150 thousand citizens formed in by our university, imagine all these people having the experience of a sustainable campus, it would sensitize them in social and environmental terms, because these people are currently working in companies, governmental agencies. They are here in our region, in other Brazilian regions, and even in other regions of the world, so I have no doubt that the social impact of sustainable practices are enormous (Interviewee 1).

With this same line of thought and also regarding the university's relations with its surrounding communities, Interviewee 13 considers that only in one of the Unisul's Campuses, in Pedra Branca, the university has about seven thousand students who must be in the university for at least 3500 h. Therefore they should contribute to the development of the university and the community in its surroundings, particularly considering that these students and faculty have an impact in the community. Further exploring this logic, these seven thousand students entering and leaving the campus, make the traffic of the residents of that community unfeasible during class periods, causing a direct impact on the lives of approximately twelve thousand inhabitants of that neighborhood (Interviewee 13). Therefore, imbedding sustainability practices in campus operations and within the community is necessary to stablish a good and positive relation with the university's surroundings.

Through sustainability practices on campus, students experience a practical learning, receiving knowledge and awareness to sustainable development, becoming disseminators and multipliers of these practices (Interviewees 2, 6 and 12). Thus, sustainability practices and infrastructure influence and inspire the internal community and the community in the university surroundings (Interviewees 3, 8 and 12).

In addition to these practices, Interviewee 4 also recognizes that energy efficiency and solar energy generation practices at Unisul's campuses, in addition to reducing energy bills, also promote students' awareness to sustainability practices and technologies. Professors can also use these technologies and sustainable structures as learning environments (e.g. electrical engineering professors who take students to assess the peaks of energy generated, how much carbon is mitigated, how many trees are saved, and other forms of study).

Interviewee 5 considers that "the example is a great way to mobilize and raise awareness" on sustainability. Therefore, sustainable campuses contribute directly to "create and demonstrate ways for students and the community to interact with these technologies", being "a great showcase for sustainability actions that can be expanded to other communities". Thus, Interviewee 9 and Interviewee 10 also believe that the experience of sustainability practices on university campuses contributes to cultural and behavioral changes.

Interviewee 11 considers the university campus as an incubator of new ideas, new habits, new technologies, then "the more the campus assumes this responsibility with sustainability, the more it forms people which will multiply these actions". Accordingly, people in contact with the campus become multipliers and disseminators of the sustainability practices, attitudes, knowledge and experiences lived on campus.

Interviewee 13 understands Unisul as a community and innovative university, concerned with meeting social demands through research and outreach, transferring knowledge and technologies to the society, promoting sustainable development. Thus, the university must penetrate the community and society must be inserted in the university, since both are part of the same ecosystem (Interviewee 13).

Considering the university campus as a learning environment and a development ecosystem, Interviewees 13 and 14 believes that campuses should be an environment for sustainability experimentation and innovation, because this practical experience transforms behaviors, attitudes and thinking, transforming these students into multipliers of the lived practices.

In addition to sustainable campus, Unisul maintains several learning and outreach projects open to the community, to train and develop their skills and resilience. Thus, Unisul also focus on events open to the community, aiming to develop a Green Agenda in the Campuses, as indicated by the university's ESD policy and program. Among the commitments of this agenda, the Green June receives great attention, with the objective of "sensitizing the academic community and the society around Unisul, about the principles, practices, premises and attitudes that we must take to achieve sustainable development" (Unisul 2017).

Through outreach and the relationship with the communities surrounding its campuses, Unisul promotes social entrepreneurship and innovations that contribute to local sustainable development (Interviewees 4 and 6). Thus, Interviewee 8 and 10 highlight the importance of developing a plan for implementing and measuring the sustainability commitment of the institution.

In addition to fulfilling its mission to train qualified citizens, Unisul engages with assistance to the communities and to the vulnerable population, through the provision of health care services, consulting in law, management and entrepreneurship, and other social services, contributing to the sustainable development of these communities (Interviewees 7 and 12).

These ESD practices help to prepare, shape and sensitize students to become "qualified future professionals who can success in the market and in society with an innovative thinking and care for sustainable development", also educating them to apply these premises in their professional performance and in their role as responsible citizens (Interviewee 7).

Among the outreach projects, Interviewees 7 and 12 indicate that Unisul has a longstanding relation with the local communities, promoting academic events open to the community, outreach courses to empower people, and research projects that stimulate local development and welfare. Interviewee 7 also considers that “events are a tool and a very important strategy for the university, to maintain and straighten the proximity among stakeholders, and the relationship between the university and the community”.

The insertion of the university in the communities, through partnerships and collaborations, contributes to the promotion of local development through the training of qualified people and the transferring of knowledge and technologies (Interviewees 9 and 12). The openness of the university to the communities also operate as a form of qualification, awareness and leisure to the local communities. Interviewee 14 highlights the importance of engaging students to develop plans to improve their local communities as their final report for the bachelor, stimulating them to contribute to the sustainable development of their communities.

Finally, Interviewee 15 observes that university campuses are references to the community in which they are inserted, therefore, the adoption of sustainable practices on campus generate an inspiring and conscientious effect throughout the community; in addition, outreach is the most direct intervention model in which the university operates in the community.

In this regard, Table 3 summarizes the practices for sustainable development promoted by Unisul to operate as a living lab for sustainable development. The interviewees indicated these practices as the main sources of ESD and innovation for sustainable development promoted by the university, also contributing to local sustainable development.

These practices open the university to the community, so besides doing outreach programs, Unisul also enables and invites the community to use the university and its facilities for learning, consultancy and wellbeing. Therefore, Unisul operates as living labs, integrating the university with its surroundings and promoting an integrated, inclusive sustainable development.

5 Conclusions and Recommendations

This study’s main goal is to understand how sustainable campuses, as living labs, promote innovations for sustainable development through the case of a Brazilian Community University, Unisul. Innovation relates to new processes, methods, technologies and institutions, aiming to promote long-term welfare, development and social wellbeing, while reducing environmental risks. As a result of the analysis we could understand that innovations for sustainable development occur in every level and sector of a university. These innovations, as observed in Unisul, occur through:

Table 3 Unisul's practices as living labs for sustainable development

Sustainable buildings and facilities	• Photovoltaic solar energy generation; • Energy efficiency programs; • Sustainable waste management: recycling, reducing waste-paper generation, selective waste separation, organic waste composter; • Rainwater collection and water reuse in the labs of architecture, engineer and chemistry; and • Waste water treatment and reuse in the water/aquatic complex
Creative and collaborative environments	• Sustainable and self-sustaining hydroponic food garden; • Innovation and sustainability in research centers and teaching methods; • The Technology Centre of Unisul, with innovation labs focused on research, technology development, analysis, teaching and learning; • The Innovation Agency of Unisul; and • Use of the organic compost to produce medicinal plants used in the courses of naturology, gastronomy and medicine
Collaboration and knowledge dissemination	• Sustainability events on campus: congresses, workshops, lectures; • Courses of short duration for capacitation and training; and • ESD programs open to both internal and external communities
Outreach	• Actions for improving the wellbeing of local communities, such as the cleaning of local rivers with the community; • The biodiesel project in a fishing community to increase the community's income and reduce water pollution from oil; • The sustainable school in Rancho Queimado, which combines the use of sustainable technologies and ESD; • The Solidarity Economy program; • The Welcoming the Immigrants program; • The participation in the committee of the Cubatão River's water basin; • Health care projects to the low-income communities, through dental clinics, medical clinics, community hospitals; • Programs of legal assistance and advice, human rights and citizenship; • Program for women's rights and education against violence; • Programs for business consultancy, stimulating entrepreneurship, internationalization and strategic management; • Programs for stimulating sports and digital inclusion; and • Collaboration with primary and secondary schools, through programs of educative games, incentives to reading and literature, health education and ESD

- The implementation of innovative management practices for HEIs, transforming behaviors and stimulating the adoption of new technologies for sustainability;
- Innovative education methodologies and practices, integrating research, collaboration, practical and active learning;
- Research, through the development of new knowledge, technologies and methods;
- Outreach, through the exchange of knowledge between different HEIs and stakeholders, promoting the development of local communities;
- The adoption of innovative practices on campus, through sustainability initiatives, decreasing HEIs' ecological footprint, stimulating learning and raising sustainability awareness in both internal and external communities.

Universities operate as learning environments to the students and the communities surrounding its campuses; therefore, these institutions can inspire, shape behaviors and influence a large contingent of people towards sustainability through the adoption of programs regarding research, outreach and education for sustainable development.

Universities and their campuses operate as living labs when allowing experimentation and collaboration among students and the community, which must be funded on sustainability's core principles. Besides reducing HEIs ecological footprint, sustainable environments act as an innovation ecosystem, guided by sustainable principles allowing practical experimentation on campus. Moreover, imbedding sustainability in educational institutions, transforming them into living labs through sustainable buildings and facilities, creative and collaborative environments, collaboration and knowledge dissemination, and outreach, contributes to the promotion of local sustainable development.

The analysis of the interviews with Unisul's faculty, suggests that sustainable learning environments enable students and professors to experience and discuss themes of sustainability and the environment inside and outside the classroom, increasing their awareness and knowledge concerning sustainability and innovative practices. Also inspiring local communities and influencing their development.

According to the interviewees, the main sustainable practices implemented at Unisul's campuses relate to solar energy generation, energy efficiency programs, waste management, rainwater collection and water reuse, the development of a hydroponic food garden, innovative research and learning environments through research centers, laboratories, innovation labs and students' enterprises.

Based on the international scientific literature and the interviewees' discourse analysis, this research presents some recommendations for sustainable campuses and development in universities. Moreover, ethics, transparency, and multidisciplinarity are fundamental principles that must be pursued by HEIs to achieve sustainable development.

- **Recommendation 1**: The construction of sustainable buildings and the renovation of existing buildings with sustainability standards.
- **Recommendation 2**: The creation of creative and collaborative environments, also enabling innovation and active learning environments.

- **Recommendation 3**: The promotion of events such as conferences, seminars and workshops focused on raising awareness on sustainable development and the sharing of sustainable initiatives and practices.
- **Recommendation 4**: The establishment of collaborations and networks among HEIs and other stakeholders, including the promotion of community outreach.

If successfully implemented and adapted to each HEI's reality, these recommendations support the transformation of the university into living labs open to the community. It, therefore, promotes local and regional sustainable development generating innovations, learning, knowledge sharing, and empowering both internal and external communities to engage with the university and its initiatives. Sustainable buildings reduces the environmental footprint of universities, while increasing the awareness of the students, faculty and the local community; collaborative environments encourage group thinking, multidisciplinary efforts and stimulate innovations; events promote sharing of knowledge, experiences, initiatives, while also encouraging partnerships and networks; multistakeholder collaborations and networks contribute to produce innovations and initiatives that improve sustainable development.

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Identifying and Overcoming Communication Obstacles to the Implementation of Green Actions at Universities: A Case Study of Sustainable Energy Initiatives in South Brazil

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Abstract Universities have become important stakeholders in the promotion of sustainable development through education and practical examples. Green campus initiatives are a way to convert unsustainable university campuses into living laboratories of opportunities for researchers and users to increase their awareness of sustainable development. However, as economic, environmental and social initiatives, the implementation of a green campus depends on changes to organizational strategic decisions and culture. This work is a case study of an university from the South of Brazil and aims to identify and overcome communication obstacles to the implementation of green campus practices in universities. The institution studied and applied three initiatives to achieve a sustainable campus. To identify obstacles to the implementation, eight interviews were conducted with project coordinators,

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researchers and operational staff from these four projects. The results demonstrate challenges for sustainable development initiatives in universities on a communication level. Based on these four cases, this article identified ways to overcome institutional communication obstacles for green campus initiatives at universities.

Keywords Green campus · Communication and information · Sustainable development · Education for sustainability

1 Introduction

Green campus includes models of action for the promotion of sustainability in universities. They consist of strategies to develop campus infrastructures with the goal of reducing negative environmental impacts and providing an environment which positively affects social development, with a focus on innovative actions towards sustainable management. Ribeiro et al. (2017) defined categories for green campus analysis. The categories are mainly linked to the maintenance of universities' internal resources, areas which negatively impact the environment or society, and large monetary expenditures. The main categories for green campus analysis are: clean energies, energy efficiency, water efficiency, sustainable transportation, education, waste management and communication for sustainability (Alshuwaikhat and Abubakar 2008; Patel and Patel 2012; Saleh et al. 2011).

Communication is essential in all spheres of life. It is a social process that starts from childhood and continues throughout the entire development of an individual (Genç 2017). It is the development and the influx of senses and information between emitters and receptors (Baldissera 2000; Pereira and Herschmann 2002). Consequences from communication failures can bring severe problems to organizations and projects. Once the information is misunderstood and continues being misinterpreted, it creates a "snowball" effect. The problem can worsen and become almost or completely irreversible. Therefore, it is necessary to establish relation channels which are able to inform students, employees, suppliers, community and the whole society, as well as to mobilize, involve, educate and introduce changes to the organization and its stakeholders. It is also necessary for this to happen continuously and permanently, not in a fragmented process, as part of a global management, with broader strategies for the creation of a sustainability culture within societies (Cabestré et al. 2008; da Conceição Golobovante 2010).

The approached topics of this article, which are communication for sustainability and green campus initiatives are directly related to the Sustainable Development Goals. These initiatives contribute to the achievement of SDG's (7) affordable and clean energy, (9) industry, innovation and infrastructure, (11) sustainable cities and communities, (13) climate action and (17) partnerships for the goals (United Nations 2018).

A series of eight interviews were conducted with managers and coordinators of green campus projects and employees in a university in the South of Brazil. These interviews aimed to determine which green campus actions were implemented in the university and investigate the obstacles linked to communication failures faced in the implementation and execution of these projects. This article inquires how communication obstacles can damage green campus initiatives in the university. From this question, this paper deepens the reflection and dialogue on green campus promotion to guarantee the execution of sustainability initiatives. This paper is divided in six sections which encompass theoretical foundations for the discussion, methodology, presentation of data, analysis, and final considerations.

2 High Education, Information and Communication for Sustainable Development

The transformational potential of communication is an important factor for the promotion of sustainable development. In this vision, communication has a more holistic role which does not limit itself to simple persuasion and behavior changes, but also involves deeper mechanisms, such as trust building, knowledge and history exchange, problem identification and the definition of solutions (Mefalopulos 2005). To da Conceição Golobovante (2010), communication in the process of development and sustainability must establish relation channels that are capable of informing consumers, employees, suppliers, communities and all parts of society, as well as, mobilizing, involving, educating and inducing changes between organizations and their stakeholders. It is necessary that communication occur continuously and permanently, with broad strategies for the construction of a sustainability culture inside societies (Cabestré et al. 2008; da Conceição Golobovante 2010).

Communication for Sustainable Development (CSD) is conceived through the planned use and participation of methods and communication tools which facilitate the sharing of knowledge and information, for the change of attitudes and practices, aimed to accomplish the sustainable development goals (Mefalopulos 2005). GTZ-RioPlus (2006) defines the five branches of Strategic Communication for Sustainable Development: 1—Development and Environmental Communication; 2—Social Marketing; 3—Non-formal and environmental education; 4—Civil society mobilization; 5—Conflict management and negotiation.

Da Costa Bueno (2012) highlights that CSD needs to incorporate a political perspective, supported by concepts which effectively contribute to the sustainable development debate, aiming to, in addition to informing, mobilize and raise awareness. It must accomplish three basic functions: promote the consolidation of the sustainability concept (broadly, incorporating environmental, socio-cultural, political and economic aspects); favor awareness about inherent risks of non-conscious consumption, waste and inequalities; report deviations and abuses committed by individuals and organizations; rescue transparency principles; harmonical coexistence and solidarity.

Universities, as institutions that prepare future leaders, are starting to demonstrate responsible actions, linking main functions of the institution with an approach to sustainability (McMillin and Dyball 2009). Educational programs for sustainability have a mission to change attitudes and citizens' values in relation to the environment and society (Arbuthnott 2009). It involves educational politics and changes in the main processes, such as increased sustainability contents and sustainable day-to-day shopping for the institution. Those linked to green campus involve campaigns to change the behavior of employees, students, and other campus users in relation to electricity, paper use, recycling, water and transportation (Djordjevic and Cotton 2011).

Campus sustainability leaders must use communication strategies, recruit active participants in order to build bridges with stakeholders and enable individuals. Universities define, collectively and holistically, the relational practices which promote sustainability and share progress reports with the public (Carpenter et al. 2016). However, communication/awareness problems and the lack of engagement are some of the barriers to sustainable action in universities campuses (Franz-Balsen and Heinrichs 2007; Horhota et al. 2014; Kataria et al. 2013). According to Adomßent (2013) challenges include: the need for structural and/or gradual changes defined by university leaders to establish communication for sustainability and interfaces among science, politics and public. Universities need to communicate more clearly the reasons for sustainability initiatives to promote stakeholder participation.

2.1 Barrier to Sustainability Communication

Communication plays a fundamental role in the promotion of sustainability and depends on strategic planning for the campus to reach everyone efficiently. However, there are barriers in this process which might hinder communication. Table 1 presents the barriers of communication for sustainability, according to pre-selected authors.

The knowledge of possible barriers in the communication process for sustainability in campuses allows for a prior strategic planning, which can soften their effects. Therefore, awareness of the campus reality's strong and weak points, measures can be taken in order to avoid some possible barriers.

3 Methods

This paper is a case study aimed at the detailed examination of the environment and/or a particular situation. The object of study is the University of South Brazil (UNISUL), located in Santa Catarina. This university, aiming for the green campus status, has implemented projects linked to sustainable development in the areas of clean energies, energy efficiency and education for sustainability. This paper aims to

Table 1 Barriers to sustainability communication

Author	Barrier	Concept
Mefalopulos and Grenna (2004), Cash et al. (2003)	Lack of the exposure of importance of communication	Lack of studies attesting the practical use of communication within diverse projects, such as decision-making, but also in the raising of awareness
Kastenhofer and Rammel (2005)	Complex interactions	Social interactions can be highly complex, presenting another barrier to sustainability communication fulfilled through "mouth-to-mouth" dissemination of information
Forman et al. (2009)	Dissemination and implementation	To implement sustainability communication it would be necessary to have professionals specialized in it in order to transmit it correctly. Nowadays, not all universities, schools and companies have such professionals
Wolfson et al. (2010), El-Zein et al. (2007), Bucur and Petra (2011)	Shifting from theory to practice	Little is discussed concerning sustainable practices, how to apply the concept to a routine, how to integrate sustainability to the multiple scopes of society, such as the economic and productive
Godemann and Michelsen (2011)	Inequalities in the access to information	Most of the information concerning sustainability is found on the internet. Lack of access is a major barrier for the full dissemination of the concept
Miller (2012)	Lack of a consensus concerning the concept of sustainability	Sustainability still does not have a common concept. Many scientists, governments and scholars do not agree on the same definition
Pedrollo and Kinupp (2015)	Bureaucracy	The excess of bureaucracy in legislation fails to empower communities, favors exploitation, and creates huge barriers for research and development

Table 2 Characterization of the sample of the interview and function in the projects

Project	Representation of the interviewee	Date of the interview	Function in the project
Solar University Initiative	Interviewee 1	10/11/2016	Coordinator
Solar University Initiative	Interviewee 2	15/11/2016	Researcher
Solar University Initiative	Interviewee 3	17/11/2016	Operational
Awareness and Education for Sustainability (PECS)	Interviewee 4	13/11/2016	Researcher
Awareness and Education for Sustainability (PECS)	Interviewee 5	20/12/2016	Coordinator
Energy Efficiency and Clean Energies in Campus	Interviewee 6	25/11/2016	Coordinator

investigate the obstacles faced in the implementation and execution of green campus projects which are linked to communication failures.

The data was collected at different times, using a semi-structured interview. The identification of the projects was from the green campus categories defined by Ribeiro et al. (2017). The script of the interview was modified to take into account the experience of the researchers in sustainability, in the literature concerning the theme and in data obtained in a pre-test. The interviews were recorded with the authorization of the interviewees and last an average of 30 min. Table 2 presents the interviewees and their respective function in the projects.

Documents were used, depending on their availability, by the managers of each project. The interviews and documents provide subjective data, related to values, actions and attitudes, opinions, thinking, personal ideas of the interviewees or university. The analysis technique of the content was made from the steps proposed by Bardin (2011), which are divided in three corresponding chronological actions: pre-analysis; material exploration and treatment of the results; and the inference and interpretation.

From theory, obstacles defined for the implementation of green campus include communication noises, presented in Table 1. These obstacles were transformed in analysis categories, and from them, the interpretation of the data was described. Lastly, the authors have analyzed the data of the interviews, documents and theory, and assembled the data triangulation, in order to make theory and practical considerations and management implications.

3.1 Project 1: Solar University Initiative

The Solar University Project is an initiative which aims essentially to disseminate an environmental education action and the culture of renewable energies for the academic community, and for that to be a base for the broad promotion of the proposal through a pilot project, which works alongside the campus library (Interviewee 1, 2016). Seventeen 4.1 kWp Photovoltaic Modules of Full Capacity were installed on the roof of the university library. "The photovoltaic modules used in the project have 245 W of potency, dimensions of 1 × 1.7 m and are manufactured with the more consolidated technology in the world (monocrystalline silicon)".

3.2 Project 2: Energy Efficiency and Clean Energies in Campus

The improvements in energy efficiency for the use of electricity can, in principle, be done in two different ways: through more efficient technology or through user behavior and habits (Henryson et al. 2000). The energy efficiency project applied in the university was only aimed at the technological matter. That is, different technologies will be applied in order to reduce consumption, and at the same time to make the university less dependent on non-sustainable energy sources. The fluorescent lamps in blocks F, G and H will be replaced with LED lamps of equal potency or higher potency to provide more light.

3.3 Project 3: Awareness and Education for Sustainability

The studied university has an Education and Awareness for Sustainability Program (PECS) which is linked to the Environmental Education Policy, and aims to become effective through actions in basic education to higher education, in all levels and modalities of study. In the educational scope, the program predicts the approach of environmental education in at least one learning unit or discipline up to graduate courses. Since environmental education can not be implemented as a specific discipline in the curriculum of all the courses, the university has defined many different forms and fronts for the dissemination of the theme.

4 Data Presentation

In this section, results of the case study about the implementation of green campus initiatives in the researched university are presented. This case study was developed with the use of primary and secondary data in the context of the projects focused on the sustainability of the University of the South of Brazil (UNISUL). From the categories defined by Ribeiro et al. (2017), were identified the two projects focused on green infrastructure in campus and another project focused on environmental education. From these interviews the authors have identified failures in communication which may compromise the success of the green campus initiatives in the university according to Table 3.

The discussion and data analysis begin in the following topic. With the data collected in the context of green campus initiatives and from the further questions generated in the subject university, the results contribute to the knowledge found in the existing, presented literature and from the information presented in Table 3. Finally the limits and possibilities for the implementation of initiatives and strategic actions of communication and green campus promotion are evaluated.

5 What Can We Learn from Data

It has been proved through the interviews and observations that all the projects presented strategic communication failures. None of them managed to establish relation channels which are capable of informing campus users, the community and all parts of society about green campus initiatives done by the university, as da Conceição Golobovante (2010) suggests. The perception of the importance of communication becomes clear in all of the interviews. However, in all the cases, the interviewees make it clear that there are no execution plans for communication in the short period.

This lack of action in communication plans can happen mainly due to the complexity of the interactions. According to Da Costa Bueno (2012), communication involves political engagement, starting from the top of the organizational pyramid to the base, involving different social actors, such as government, civil society and non-governmental organizations. The hierarchy is strong inside the university and it has distanced from working classes and has created perceptions that some are "more heard" than others. It is clear in the affirmation of Interviewee 6 (2016), that the project was started without the knowledge of the university because the lack of communication regarding sustainability efforts to managers, especially in regards to cost.

Another fact in communication failures are the inequalities in information access. In the Solar University initiative, the responsible employee did not know basic data about the project, such as its objective or publicity. He did not communicate with the managers or get information about the initiative in eight months. The same way that the manager of the project did not know which employee was responsible for the operacional monitoring of the project. In the PECS, the problems in access to information was related mainly to the failure in promotion inside the campus. Although the project comes with a website it is out of date, including researches who do not integrate the group anymore. An alternative to mitigating the problem of inequalities

Table 3 Proposed categories, their properties and manifestations

Project	Initiatives types	Interviewees manifestation	Barrier
3.1	Renewable energy	"It does not have a continuous action about communication […] The project is bringing results and we are losing this institutional memory" (Interviewee 1, 2016). "Today since we have not implemented a management for the sustainability sector in the university […] from the moment you do isolated actions you can not continue in the projects […] Today the project can be six months with half of the panels not working and no one will know" (Interviewee 3, 2016)	Lack of the exposure to the importance of communication
3.2	Energy efficiency	"[…] it is part of the project, since it is in the implementation phase, little by little the schedule is being respected and fulfilled" (Interviewee 6, 2016)	
3.3	Environmental education	"We do not have a communication action in relation to the project. What is aimed to do is a website for the program (Interviewee 4, 2016). "We need to perfect the communication matter […]" (Interviewee 5, 2016)	
3.1	Renewable energy	"I do not know who makes the close monitoring of the project […] and the dissemination of the sustainable energies" (Interviewee 1, 2016)	Complex interactions
3.2	Energy efficiency	"This project has started, in the beginning separate from the university. Only later did the university learn about it, when the project was practically done" (Interviewee 6, 2016)	

(continued)

Table 3 (continued)

Project	Initiatives types	Interviewees manifestation	Barrier
3.3	Environmental education	"It is a challenge. It needs to have a work group. It needs to have people in the campus to promote the idea. Also mainly because it is a demand from MEC (Ministry of Education)" (Interviewee 4,2016). "Presently all campuses are involved. However, we have to expand even more the opportunities and possibilities for students and teachers, and consequently, help more the community surrounding the university" (Interviewee 5, 2016)	
3.1	Renewable energy	"An interesting step would be to make available the data concerning energy generated directly by panels in the WEB […]" (Interviewee 1, 2016). "A hardship in this moment is the lack of monitoring. If there was a software to monitor this functioning […] such as an online one" (Interviewee 3, 2016)	Dissemination and implementation
3.2	Energy efficiency	"It is predicted in the project planning, approved along with the dealership, awareness and a propagation of this idea, mainly online" (Interviewee 6, 2016)	
3.3	Environmental education	"A weak point is the aderance of teachers and coordinators […] it is still fragile, a work in progress" (Interviewee 4, 2016). "Another strong area we have is communication, which we call communication and schedule […] But it is communication through the mediums of the university, such as, TV or Newspaper. But we do not have a marketing for awareness" (Interviewee 5, 2016)	

(continued)

Table 3 (continued)

Project	Initiatives types	Interviewees manifestation	Barrier
3.1	Renewable energy	"Although we have a resolution by Anel which states that the dealerships are prepared to receive the generated energies […] there is still a certain difficulty with the orientation process for the installation of the micro energy generation. There is not a departament prepared with fast solutions for the installation of micro-energy production" (Interviewee 1, 2016)	Shifting from theory to practice
3.2	Energy efficiency	"We are having some trouble with the manufacturer […] there was a problem with the delivery of some pieces and consequently problems in the execution schedule of the project" (Interviewee 6, 2016)	
3.3	Environmental education	"We still have low adherence by teachers and students. It has changed a lot, and it has been changing more, but we need even more adherence for a larger contribution" (Interviewee 4, 2016). "[…] we begun to call teachers and let them know we had created a program which needs promotion, and we started an official online page of the university. But, we put in a special section which is 'get to know the university" (Interviewee 5, 2016)	
3.1	Renewable energy	"I do not know who has worked in the implementation, because when the project arrived, it was already done and not many details were provided to me" (Interviewee 3, 2016)	Inequalities in the access to information
3.2	Energy efficiency	The work is concentrated on only one person, only one teacher. There is no direct participation of other professors or students (Observation)	

(continued)

Table 3 (continued)

Project	Initiatives types	Interviewees manifestation	Barrier
3.3	Environmental education	"Not all courses have access to the program, therefore, we are making a move inside the campus, talking to coordinators and professors" (Interviewee 4, 2016)	
3.1	Renewable energy	Despite different opinions, all interviewees have their sustainable development view based in the Brundtland report	Lack of a consensus concerning the concept of sustainability
3.2	Energy efficiency		
3.3	Environmental education		
3.1	Renewable energy	"Santa Catarina is one of the few brazilian states which still does not have the reduction in the ICMS for those who have photovoltaic energy generation" (Interviewee 2, 2016)	Bureaucracy
3.2	Energy efficiency	"We had great hardships, for example, the university was not used to it. The money is public, so it demands that the university has all things cleared with the government, free of Federal Revenue, INSS and State Revenue prosecutions and once in a while these problems happen and block the project" (Interviewee 6, 2016)	
3.3	Environmental education	"The project was implemented because of need, since the university is communitary, but also motivated a lot by the evaluation tool of MEC" (Interviewee 4, 2016)	

in information access could be to share progress reports of the sustainability actions, as suggested by Carpenter et al. (2016).

Dissemination and implementation are strategic for the success of any project. They will ensure the access to all of the information regarding the initiative. The main failure in all projects is the lack of relations between sustainable initiatives and the classroom, since this is one of the main goals of green campus. Everyone recognizes the digital environment as the new way to propagate information and promotion. The digital environment has made this task easier as online propagation of the results ensures a broad and unrestricted access to data (Ribeiro et al. 2017).

The fact is that the digital environment must not be the only way of propagation for it is much more on theory than in a practical one. Knowing how to apply the green campus concept demonstrates a shift from theory to practice. That becomes clear when analyzing the objectives and initiatives and the realities in which they are found. In the case of the Solar University, the project had as an objective to raise awareness in students. The project was used by the teachers as a source of content and for analysis since the situation of the project is presently unknown. In the PECS website, there is a great amount of out of date information that has not been seen in practice. In the implementation of Energy Efficiency the difficulty was keeping the project within the schedule, mainly because of the lack of experience of the managers, or some inadequacy of the university and their commitments with the State, which demonstrates the hole between the formation of the green campus ideas and its applicability and execution. The appointment of a leader to establish communication for sustainability and the interfaces among science, politics and the public, besides structural changes which could be adopted in order to overcome these barriers (Adomßent 2013).

In this aspect there is bureaucracy. It can be within the university, or outside of it, coming from the States. Although bureaucracy is important for control, in some moments it can be a huge barrier for the progress of some projects. In the case of the green campus initiatives and in the Brazilian case, research has identified bureaucratic hindrances in the access to technology, mainly those imported. In the scope of the state, the projects financed by the government are followed with unclear legislation, opening space for different interpretations and generating insecurity on the promoters. For a unique demand, sometimes, different documents are required, containing the same information. Within the university itself this problem is also identified, since there is not a university plan for sustainable development, so the consequences are an excess of different demands for the same case.

Despite all the hardships concerning the implementation of green campus initiatives in the university, all the managers and interviewees have a sustainable development vision aligned with the Brundtland report. That demonstrates a certain degree of knowledge and research by the employees, but not a lot of practice which, once more, takes back to the idea that theory is far away from practice. Creating a control environment for these initiatives can be a step ahead for the university to better manage the challenges faced in green campus initiatives.

5.1 *The Institutionalization of Sustainability in the University*

A point which would be worth exploring would be the creation of an office, or sector, especially focused on sustainability. The New South Wales University, in its annual report about sustainability presents one of its objectives as integration, communication and engagement (UNSW 2015). That is, the need for integration between projects, results and objectives. The University of Harvard has the Harvard Office for Sustainability (OFS), which leads a changing initiative in all the university's organizations in order to establish, control and reach goals for a healthier and more sustainable future (University of Harvard 2016).

An office focused on sustainability would enable the coordination of all the projects and would be responsible for the control and evaluation of the initiatives. Presently, the researched university does not have any type of quantitative control for evaluation of green campus projects. Another point, is that in the analyzed projects no one knew the impact that the projects could have over students and community. According to Kamp (2006) and Mulder and Werk (2004) first there is a need to help campus users to acknowledge that sustainable development involves actions which do not degrade the environment and that are made from renewable resources. Second, to teach that part of the sustainable development is linked to a broad social context. Lastly, to teach users that the "lucrative" part involves making a positive contribution in the long term for society, from which comes the profits of the company. Generally, behavior is what will bring success to the initiatives for sustainability, and without a doubt information is the source and communication is the tool to inform.

6 Conclusion

Communication failures were preponderant for the lack of success of the projects. The information which is not transmitted means nothing. Communication is what makes information transit between individuals and that way allows publicity of a determined idea. The analyzed projects make these situations clear where an individual has the information, and what has been causing the failure of the projects applied in the university campus. In PECS the failures and clarity in communication caused professionals to be unengaged and uninterested in developing the idea. Another example, is the launching of a new green campus project which involves renewable energies which does not take into account the results or connections with a similar existing project. In a more serious case, the operational sector of the project went months without communicating with the main managers and presently, some of the photovoltaic panels might not be working either.

In these situations, the intermediation of the university would be important, it could concentrate and bring ideas together, contribute to the 2030 Agenda and the SDG's, as well as solve communication problems that can happen during the implementation of the projects. This paper suggests the creation of an office focused on sustainability in the university, which would be responsible for monitoring all activities related to the theme. Solutions for communication problems are not expensive, unlike the development of engagement cultures by campus users. This article aimed to show how communication failures are being neglected and ignored by university managers.

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Mobilising the Sustainable Development Goals Through Universities: Case Studies of Sustainable Campuses in Malaysia

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Abstract The 2030 Agenda as adopted by the United Nations General Assembly paves the way forward for planet, people and prosperity—an Agenda that replaced the Millennium Development Goals, to the Sustainable Development Goals (SDGs). The SDGs consist of 17 goals, 169 targets and 232 indicators. Essentially the goals exist to address sustainability holistically, covering all dimensions including economic, social, cultural and ecological. The United Nations has identified Goal 4: Quality Education as one of the main drivers in achieving the Agenda. This paper focuses on specifically Target 4.7: Education for sustainable development and global citizenship. Universities play a vital role in engaging youth and generating knowledge and expertise in understanding and implementing the SDGs. This paper explores the role of universities in ensuring the SDGs are met, as a mobilizing catalyst for accelerated implementation, as well as case studies of sustainable campuses in Malaysia that showcase the community and student outreach projects, in line with the SDGs, such as the Bicycle Project at the University of Nottingham, Malaysia Campus, *Kompos to Kelulut* (K2K) at the Universiti Sains Malaysia and Sunway Youth for Sustainable Development at Sunway University, Malaysia. The case studies show that education goes beyond the formal curricula, emphasizing on soft skills and critical thinking—a major component of and contributor towards pro-environmental behaviour. A set of recommendations are included to address limitations in the study.

Keywords SDGs · Universities · Sustainability · Sustainable campus

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1 Introduction

The United Nations Rio + 20 Conference in 2012 witnessed the establishment of the Sustainable Development Goals (SDGs) by 193 countries (United Nations Development Programme (UNDP) 2015). The SDGs replace the expiring Millennium Development Goals (MDGs) in a post-2015 setting, with a vision of achieving the 2030 Agenda. The purpose of the SDGs is to stimulate governments and civil society to step up and address the interrelatedness of environmental, societal and economic challenges that we face today (Norström et al. 2014). Although the previous MDGs was a historic pioneering set of goals for global mobilization, it has been critiqued for having a narrow focus on the human development, whilst neglecting the significance of natural capital and ecosystem services (Sachs 2012). There are also little cross-referencing between targets and indicators, as well as lack of universal ambition for transformation of sustainability pathways (Norström et al. 2014). Unlike the MDGs, the SDGs puts forward a unified universal framework to enhance human prosperity in the Anthropocene, where the global environmental risks are ever rising (Griggs 2014).

The urgency for sustainable development is apparent as the triple bottom line approach is key towards determining human wellbeing (Sachs 2012). Nearly all of the world's societies expressed that they strive for a holistic collaboration of economic development, environmental sustainability and social inclusion. However, specific objectives may differ globally and between societies. Nonetheless, this proves that the SDGs concerns everyone and has to adopt an intersectoral approach in terms of implementation across levels. The 17 goals, for example, highlight different areas of focus in achieving a sustainable future. Goal 4 in particular, represents quality education.

Education represents the most fundamental process of facilitated learning, to inhibit knowledge, values, skills and habits. Education is so important that the United Nations called for the International Decade of Education for Sustainable Development (IDESD) in 2005. The purpose of IDESD is to provide a platform to integrate the values, principles and practices of sustainable development in education and learning holistically. UNESCO (2005) stated that education for sustainable development (ESD) is set to review educational approaches to ensure that they were up to pace with the evolving challenges of sustainable development. Ultimately, the goal for IDESD was to encourage behavioural change in hopes to achieve a more sustainable future, especially in terms of environmental integrity, economic viability and a just society for all (UNESCO 2005).

At higher institutional levels, ESD is most likely to be associated with integrated curriculum structure in individual modules or as part as a larger course. However, this is not often the case. The SDGs are taught in various methods and via a myriad of platform. More often than not, the SDGs are incorporated in extracurricular activities, may it be student, faculty or campus community led. Mendes (n/a) mentioned that universities management were not essentially aware of UN campaigns, thus leaving the task of action and implementation to individual academics, and people interested in international cooperation. The existence of pockets of implementation by conscious individuals shows that there is a lack of coordinated approach at all levels of institution (Mohamedbhai 2015).

1.1 Aim and Objectives

The overall aim of this paper is to compile and analyse case studies of sustainable initiatives in universities in Malaysia as best practices that can be adopted by other universities moving forward the sustainability agenda. The reason that this paper was put together is to reach the objectives as below:

(1) To showcase proactiveness of campus community in Malaysian universities in implementing sustainable initiatives and the localization of SDGs via case studies of existing projects.
(2) To identify the factors affecting positive change in campus sustainability to further enhance the implementation of SDGs in universities.
(3) To provide recommendations to improve the advancement of ESD and sustainability initiatives of universities in Malaysia.

2 Understanding Sustainability in Malaysian Universities

In Malaysia, there are different models of higher education institutions, which include mainly public universities, polytechnics, private universities, foreign universities branches and private college (Saadatian 2011). Different models of HEI have different operational procedures. Public universities are funded by the government, of which five of these universities obtained “Research University” status. Private universities and colleges are universities and colleges set up by financially sound corporations and monitored by the Ministry of Higher Education (MOHE) of Malaysia. Currently, Malaysia has 20 public universities, 43 private universities, 31 private colleges, 9 foreign university branches and 34 polytechnics (StudyMalaysia.com 2016).

According to Mohd et al. (2011), the definition of a sustainable campus is based on its operations, social and economy that promotes long term survival of the environment and respective social structures. Another definition of sustainable campus as developed by Cole (2003), Velazquez et al. (2006) and Habib and Ismaila (2008) put emphasis on well-being and health being the main characteristic, in leading towards a better balance between social, economic and environment. In general, a sustainable campus would cover four areas of university community, which include the administration, academic departments, university research efforts and local community (Kasim and Ujang 2014). Local studies done by Kasim and Ujang (2014) and Abd-Razak et al. (2012) suggest that planning and design of the campus play an important role in developing a healthy environment, thus better support the sustainability of campus.

There is a considerable amount of environmental awareness in regards to achieving sustainable campus in Malaysia (Megat Abdullah 2014). Many universities are encapsulated with monitoring energy consumption and waste, while others focus on fundamental basics such as recycling and separation of food waste. The levels of sustainability in Malaysian university campuses varies as some are merely in the pioneer stage while others are veterans in the field.

3 Methodology

Due to the contemporary nature of this research paper, the methodology used is case study. The case study methodology incorporates various techniques such as reviewing literature, interview, and observation, were utilised during the data collection phase to gather more source of evidence.

Literature searches of electronic journal databases were conducted for background studies of sustainability in universities. The key words used were 'SDGs', 'sustainability' and 'universities' and 'sustainable campus'. Interview with key person in charge of leading the projects in each of the campuses were carries out to further understand the depth of the projects. On top of that, observation is a technique that was applied to observe the behavioural and visual aspect of the campus, which includes composition, form and appearance of the university (Shuhana et al. 2007).

The three campuses and projects were selected based on the correspondent author's involvement in previous years, which are the University of Nottingham, Malaysia Campus's Bicycle Project from 2015–2016, University Sains Malaysia's *Kompos to Kelulut* in 2017 and Sunway University's Sunway Youth for Sustainable Development in 2018. The authors worked closely with key person in charge at every university to ensure accurate representation of information.

4 Case Study Particulars

The University of Nottingham Malaysia Campus (UNMC), Universiti Sains Malaysia (USM) and Sunway University (SU) were selected as case studies. The three selected universities are very diverse, with UNMC being a foreign university branch campus, USM being a public university and SU, a private university. There are different approaches being made to tackle sustainability issues in each universities as well. This paper showcase the best practices for sustainable campus initiatives, regardless of the university background or approach, for a common goal.

4.1 The Bicycle Project, the University of Nottingham, Malaysia Campus

The University of Nottingham, Malaysia Campus is situated about 38 km from Kuala Lumpur, in a quiet town in Semenyih, Selangor. It is the first UK campus in Malaysia, and one of the first to open outside the UK. The Malaysia Campus was set up in 2000, and moved to its current location in Semenyih in 2005. The total enrolment of students in UNMC is at an estimate of 5000 people in 2016. It is considered a relatively new and small campus, which in turn creates a rather intimate connection between the campus community.

The campus mimics the attributes of the University Park Campus in the UK, spanning about 50.6 hectares, with lush greeneries and man-made lake in front of the iconic clock tower. The university has four faculties, which comprise of teaching staff from the UK Campus, as well as competent international and local lecturers as well. All students take part actively in co-curricular activities under the Student Association (UNMC 2018). Many sustainable initiatives in UNMC is through bottom up approach, from Bring Your Own Tupperware initiative, to getting more recycling bins on campus.

As students become more environmentally cautious, so does the university. In 2015, a group of students gathered together to carry out the UNMC Bicycle Project. Co-founded by Jasmin Irisha Jim Ilham and Malik Hisyam Zaihan, the UNMC Bicycle Project aimed to provide an alternative mode of transportation via cultivating cycling culture, lowering the amount of campus carbon emission from motorised vehicles, and encouraging a healthy lifestyle among the campus community. Demographically there are two initial reasons as to why the Project was carried out. The local students were facing a parking problem on campus, as there were too many students who drive, and lack of parking space to cater to the number of vehicles. On the other hand, international students, mostly UK and EU students, were very interested to rent bicycles—a service that the campus did not offer.

A team of students who primarily cycles to campus were put together, and in collaboration with the Sustainability Research Network, conducted a campus wide survey to gauge interest towards cycling. Based on the survey, 69% of respondents expressed their interest in having a bicycle rental system on campus. As a result, a proposal was drafted and presented to the Campus Services director, seeking support to implement a small-scale bicycle rental system to run as a pilot program, initially planned to be ran by students.

This also led to the conception of UNMC's first ever Cycling Club, to provide a platform for students to not only cycle together but champion for sustainable transportation. As the Bicycle Project had a timeframe towards the implementation of it, the team was thinking in terms of long term planning and sustainability. Thus, the Cycling Club was established to not only provide a common platform for interested individuals to gather and form a community, but also to overlook the progress of the Bicycle Project and the accountability of it.

Through multiple meetings and discussions, the Director of Campus Services showed his support for more bicycles to be brought into campus, although questioned the feasibility and sustainability of it. The idea of bringing in e-bikes was toyed around with but did not eventually become a reality. The emergence of oBike in Malaysia provided just the solution, as the company had intended to have a presence in university campuses. Bicycles provided by oBike were welcomed into UNMC and saw many students pick up the habit of cycling to get from one end of campus to the other. UNMC has also incorporated "Bicycles" as part of their Campus Sustainability portfolio.

The UNMC Bicycle Project was purely a bottom up, grassroots movement, led by the students themselves.

4.2 Kompos to Kelulut (K2K), Universiti Sains Malaysia

Universiti Sains Malaysia (USM) is located on an island state on the northwest coast of Peninsular Malaysia, called Penang or Pulau Pinang. USM was founded in 1969, and is one of the oldest institute of higher learning in Northern Malaysia. It had around 24,375 students enrolled in 2016, making it one of the biggest universities in Malaysia in terms of enrolment. It is also large in terms of space, taking up 416.6 ha site (Universiti Sains Malaysia 2018).

USM is no stranger in the realm of sustainability in higher education. Besides being one of the leading research universities in Malaysia, USM is committed to focus on "transforming higher education for a sustainable tomorrow." USM is well recognised as a Regional Centre of Expertise (USM-RCE) for education for sustainable development membership, taking part in the Kampus Sejahtera (Campus Well-Being) Programme, and most of all, gaining the Malaysia's Accelerated Programme for Excellence (APEX) status.

The strength of USM's ability to push forward the sustainability agenda lies in the commitment of campus faculty to lead and be the agents of change. One of the successful examples in particular is the project under the School of Industrial Technology, Compost to Stingless Bees, better known as *Kompos to Kelulut* (K2K). The K2K project started in 2014 through Knowledge Transfer Programme, a research grant awarded by the Ministry of Higher Education for University engagement with Industry and Local Community. The Knowledge Transfer Programme awards researchers from local Universities to share their knowledge from their research with the Industry and local communities for 2 years. It is to train fresh graduate as Graduate Intern other than empowering local community or the Industry on the technology from the projects conducted.

The K2K project was led by Professor Dr. Mahamad Hakimi Bin Ibrahim from Ecoprocess Research Technology Group (ECOPRO@USM), the School of Industrial Technology. The project is a continuation of an existing research on Composting and Vermicomposting which started in 2010. At the time, the purpose of the project was only for research in which 8 Master students and 3 PhD students graduated from various studies on Composting and Vermicomposting. The K2K project grew into Rooftop Wild Garden as ECOPRO searched for a space to grow plants using compost produced during the composting and vermicomposting research. ECOPRO identified the Rooftop as a suitable space to start a wild garden based on the concept of zero waste, zero space and zero time.

At the same time, the extra compost was deposited on a nearby the school, called Bukit TI. It is deemed the Green Technology Garden, and was approved by the Vice Chancellor of USM. Here, Bukit TI is used as a teaching and training centre for local community from inside and outside of USM to learn about K2K project, Ecosystem Design & Restoration. Visitors come from local and international universities, government agencies such as Forest Research Institute Malaysia (FRIM), community colleges, schools, private sectors and the local community.

This project also creates volunteering opportunity for USM students and local community to learn and participate in greening Bukit TI. Workshops are often conducted such as Eco Soap, making their own Effective Microbe (EM), Sistem Kompos Mudah (S.K.M.) composting method and various method of composting and vermicomposting to enhance the skills and knowledge of the volunteers. Ultimately, the project aims to grow a 'USM Community Garden' as an initiative using Green Technology as well as Ecosystem Design and Restoration.

Having a faculty to lead changes and contributing to the sustainability of the campus is one of the main driving forces for the advancement of sustainability of the university.

4.3 Sunway Youth for Sustainable Development, Sunway University

Sunway University (SU) is located 16 km away from the Kuala Lumpur city center, in Bandar Sunway, Subang Jaya, Selangor. The university was first established in 1987 as Sunway College, then upgraded to university college in 2004, followed by a full university status in 2011. It has over 5000 student enrolments and is owned and governed by the Jeffrey Cheah Foundation.

As a leader in sustainability, SU champions the United Nation's 17 Sustainable Development Goals (SDGs), demonstrating the university's effort in building a sustainable future for all. SU supports sustainability initiatives via constantly pushing forward the best minds to discover new ideas in pursuing environmental and economic issues. In line with the goal of creating a sustainable future for all, SU hosts the Jeffrey Sachs Centre on Sustainable Development (JSC), which is a collaboration between the Jeffrey Cheah Foundation and the United Nations Sustainable Development Solutions Network (UN-SDSN) (Sunway University 2018).

As part of the university's sustainability framework, the Sunway Youth for Sustainable Development (SYSD) was established, and co-founded by Natasha Ting and Shakirin Shahrul in 2016. The society aims to raise awareness about the SDGs among Sunway University stakeholders and advocate for the realization of solutions on campus. It would also serve to collaborate with regional organization to work on implementation of the SDGs. In 2017, a committee of students from Sunway University were appointed to the committee of SYSD to champion these goals on campus, under the supervision of JSC.

SYSD is established as a platform for Sunway University students to be more involved in projects and activities related to the causes under the 17 SDGs. For instance, SYSD had organised its inaugural event, Earth Week, to bring students together and expose them with the 17 SDGs. These goals are important guidelines to reduce societal as well as environmental problems in today's community. Activities like Earth Week aims to embed the motivation and drive for students to be a change maker and a change agent in their respective communities.

SYSD was formed as a result of an organised framework structure in order to implement the SDGs effectively in the community.

5 Discussion

The three case studies put forward in this paper showcases the different projects and approaches leading to a sustainable campus in Malaysia. From solving urban transportation issue, to nature based initiatives, to youth champions for SDGs, there are many ways for sustainability to be practiced and implemented in higher institutions. In the progress of developing sought after graduates in this era, sustainability in pedagogy through ESD is not enough, it has to come with experience and hands on engagement, harnessing soft skills and critical thinking amongst students. According to Reza, Choy and Pereira (2013), field-based pedagogical approach is effective and helps students understand sustainability from a broader perspective. This chimes in with the case studies that were presented, as it does not resonate with the formal curricula. These "Sustainability in Practice" examples may not cater towards the usual pedagogical approach, but is important as it outputs an immense impact on society (Reza 2016).

5.1 Localisation of SDGs

The Government of Malaysia recently launched a Voluntary National Review (VNR) 2017 of the SDGs at the High-level Political Forum. Localisation of SDGs can be identified by mapping the 17 SDGs, 169 targets and 232 indicators against the current 11th Malaysia Plan, themed "Anchoring Growth on People." The VNR acts as testimony for Malaysia's continuous commitment to achieve the 2030 Agenda and the SDGs (VNR 2017).

The 17 SDGs is universal and transformational, providing a guide on addressing major development challenges for humanity. The case studies portrayed in this paper acts as a medium of localisation of SDGs, and an impactful, local outcome. For example, the UNMC Bicycle Project relates to SDG11, sustainable cities and communities, K2K relates to SDG4, quality education and SYSD relates to SDG17, partnership for the goals.

Leaders in local communities have the responsibility to align SDG framework and national policies together, making localisation of SDGs a priority. En route to achieving the 2030 Agenda, implementation of the SDGs at a local scale is critical. Among the main points moving forward from the VNR include localising SDGs at sub-national levels via adopting the national multi-stakeholder governance at state levels, mobilisation of resources through partnerships and knowledge sharing to strengthen data readiness for a more comprehensive dataset for implementation of SDGs (Sustainable Development Knowledge Platform, n/a).

5.2 Factors Affecting Positive Change

There were several questions that spurred up from analysing the projects from the case studies:

1. What drives the motivation for students and staff to carry out their sustainable projects?
2. Does the awareness of students and campus community on sustainability reflects the overall campus sustainability? Or does the readily available sustainable campus facilities enhance awareness of students and campus community?
3. How does one ensure continuity of the project, and influence others in respective circles to adopt the same practices?

Pro-environmental behaviours are evident in the co-founders and project leaders, despite the project being a grassroots movement or a product of an institutional set up. They recognised that there are several environmental problems that encroach the world and pose a threat to sustainability, that include climate change, anthropogenic pollution and biodiversity loss (Steg and Vlek 2009). The direction of environmental education is currently shifting, through *reorienting higher education* process (Akiyama et al. 2013). The process shifts the traditional knowledge on environmental education and sustainability towards integrating that curricula to establish a role that higher institutions can play.

The emergence of not only environmental leadership, but also youth leadership was observed in all three case studies. The UNMC Bicycle Project was independently co-founded by students, the K2K USM project hones undergraduate and graduate students to volunteer and take up research in field, and the SYSD SU team of organisational members fully comprised of university students. This reveals that modern day sustainability extends beyond sharing existing scientific knowledge, but walking the talk from what was learned within the four walls of a classroom. Akiyama et al. (2013) argues that Asian universities is relatively slow and distant from global movements of networking in environmental education and leadership development, as well as lacking active involvement in participatory leadership programmes. This is highly debatable for universities in Malaysia, as there is an improving trend that higher institutions are adopting sustainable practices, as SDGs as an international framework has become a national agenda.

The question on the awareness affecting campus sustainability against readily available sustainable facilities affect the campus community awareness is a chicken and egg dilemma. To achieve whole-of-institution change and adopt a holistic sustainability approach to the universities, there are a number of criteria to take into consideration, which primarily starts at an institutional level. Universities with clear goals and strong sustainable policy directions will be able to advance ESD more smoothly (Ralph and Stubbs 2014). However, will this translate into pro-environmental behaviour change and increase in environmental awareness? Behavioural change and awareness takes time, and is dependent on the effectiveness of the environment and surrounding influence in influencing pro-environmental choices and decision. For example, a student is more likely to recycle if recycling bins are easily found around the campus, because it is convenient for them. But what happens when there are no recycling bins that can found around? The student will most likely to discard the recyclable disposals in a trash can.

What the three case studies have in common is that they provide a platform and avenue for the campus community to be more environmental cautious and to increase awareness on sustainability. The UNMC Bicycle Project aims to provide a bicycle rental service, to encourage more people to cycle, the K2K USM project dedicates an outdoor space for nature based learning, catering to hands on experiential training and reconnecting human back to nature, whereas SYSD SU is a common platform for youth to learn from one another to enhance youth leadership in sustainability, hence organising activities to further inspire others to be more aware on the environment.

Continuity of sustainability projects in universities is vital to ensure that more campus community can benefit from them. A key success factor that is identified through the three case studies is *people*, particularly *committed individuals.* People who hold leadership roles in the projects are responsible for the operational and implementation of the project. Other attributes that are important to maintain the sustainability of the projects is commitment and funding. Hence, capacity building plays a fundamental key to ensure continuity of the projects. Being able to identify key potential individuals to carry on what was started is a challenge, but is definitely needed. It is considered a challenge as universities has a high turnover rate, as students only spend three to four years in a university.

5.3 Limitations and Lessons Learnt

The key success factors are also key limitations that were identified in determining the success of projects. In moving forward, it is pertinent to address leadership, funding, policies and human resource challenges. The case studies did not highlight the timeframe, manpower and number of activities carried out per year. These attributes would influence the effectiveness of the projects and how the projects are able to outreach to the community and achieve goals accordingly. A multifaceted approach can be adopted in advancing ESD and sustainability initiatives on campus, that include:

- Establishing a sustainability framework in universities to govern, enhance and support the strategic directions of environmental sustainability on campus;
- Consistency in funding being allocated to sustainability initiative to encourage students and staff to carry out sustainability initiatives and integrate sustainability in the curricula;
- Engaging with environmental leaders and advocates within the university to mobilise the sustainability movement and create awareness in the community;
- Providing capacity building training to hone skills to staff and students of the university to further understand the university's environmental sustainability principles, directions and policy (Ralph and Stubbs 2014).

6 Conclusion

Universities play important role in shaping the leaders of the tomorrow, today. Progressing closer to 2030, the importance of achieving the 2030 Agenda has increasingly become a priority for universities that put forward Sustainable Development as one of the key areas of development, emphasising the SDGs to be embedded as core values and principles in the everyday teachings and activities. Adopting best practices from the case studies could elevate universities in Malaysia in terms of sustainability, making universities in Malaysia align with the global United Nations standards, thus increasing the university's performance in producing more valuable and holistic graduates that are environmentally conscious and sustainably aware of the present condition of the planet.

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Towards a Learning System for University Campuses as Living Labs for Sustainability

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Abstract Universities, due to their sizeable estates and populations of staff and students, as well as their connections with, and impact within, their local and wider communities, have significant environmental, social and economic impacts. There is a strong movement for universities to become leaders in driving society towards a more sustainable future, through improving the sustainability of the built environment and the universities' practices and operations, and through their educational, research and wider community engagement missions. Around the globe the concept of 'Living Labs' has emerged as an instrument to integrate these different aspects to deliver sustainability improvements, through engaging multiple stakeholders in all of these areas, and through the co-creation of projects to improve the sustainability of the campus environment and operations, and to link these to the education, research, and wider community missions of the institution. This chapter describes a living, shared framework and methodology, the 'Campus as Living Lab' learning system, created through global participatory workshops and Living Lab literature, aimed at supporting universities and their Sustainability (Coordinating) Offices in the development and monitoring of Living Lab projects. The framework includes seven categories of supportive data collection and three levels of details to meet different requirements of potential users. The Living Lab framework presented in this chapter, aims to create value and help universities maximise the benefit of

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Living Lab projects within an institution, support monitoring, reflection and learning from projects, and facilitate communication with stakeholders, and the sharing of practices and learning between peers across the globe. As a living shared, framework and learning system, the framework will adapt and develop over time and within different contexts. To provide feedback and fast (practical) learning from users, the system will be further developed to facilitate transparent peer reviewing.

Keywords Living labs · Co-creation · University sustainability

1 Introduction

There is increasing emphasis on the need for universities, or more generally institutions of higher education (HEI) around the world to play an increasingly important and critical role in society's movement towards a more sustainable future. HEIs as institutions with diverse missions and large estates are well placed to contribute to this agenda in unique ways, through: their education; their research; their wider community involvement, including business, government and community stakeholders; through their estate; and through the integration of all four of these areas. The substantial size of these institutions, often equivalent in area, population, and activities, to the size of a small (or not so small) town, as well as mostly part of a city system, creates an imperative to improve the sustainability of the estate and operations of the university campus.

Whilst the integration of the estate, education, research and wider community aspects within a HEI provide opportunities to use the campus to research and trial more sustainable solutions, and for the outcomes and processes of this research to be used in diverse ways to educate the HEI and wider community about sustainable solutions. The university campus and in some cases as well its neighbourhood therefore becomes a test bed, or 'living laboratory' (from now, 'Living Lab'), where solutions to increase the sustainability of the university estate and operations are researched and trialled, and integrated into education. The Campus as Living Lab framework seeks to leverage the maximum benefit to sustainable practice across all areas of a university's mission and operations.

The Living Lab approach aims to use research conducted within the university aimed at advancing sustainability principles across different levels of impact: the HEI's estate and operations; the educational curriculum; across the university and wider community; and society. To advance successfully the integration of sustainability principles across our campus operations and the built environment, we must have a deeper understanding of what works and what does not work. To successfully advance the integration of sustainability principles within the educational programmes and wider student (and staff) experience of the HEI, we must know what processes lead to desirable educational outcomes, and how best to integrate the research *process* and sustainable estate *product* most effectively into these areas. To bring forward the integration of sustainability principles within the wider communities of HEIs, we must understand how to communicate effectively with various stakeholders to boost a socio-ecological (sustainability) transition.

Questions that HEIs must tackle, to help advance sustainability principles in society include: How do we make informed decisions that lead to decreased environmental and human health impacts locally and globally? How do we plan for our campuses and cities to be resilient to a changing climate—today and in the future? How can our campuses and their neighbourhoods mitigate greenhouse gas emissions to the extent called for by the IPCC? These are the types of questions that warrant a shared framework to advance successful living labs on campuses, globally. Universities are now poised to leverage their unique ability to be a scalable laboratory in which to devise, pilot, implement and evaluate the best sustainable organisational to urban scale strategies of today and the emerging next-gen strategies for tomorrow (Newman 2018).

The concept of an HEI as a Living Lab is relevant to HEIs all across the world. Yet the context in which HEIs exist both within and between countries varies significantly (den Heijer 2011). For example, HEIs may be city based, with buildings distributed across a city; maybe campus based, with buildings housed within a single (or multiple) estate; they may be urban or rural. HEIs in different climatic environments across the world also face very different sustainability issues to address; for example, whether major energy costs are associated with heating or air conditioning. Governance structures for sustainability vary significantly between institutions, some have Sustainability (Coordination) Offices, some have more distributed sustainability responsibilities. Cultures within HEIs in different countries also differ, as do cultures between different HEIs in the same country. Within HEIs there are also diverse cultures of practice, between students, academic staff and faculty, professional services support staff, and estates operations staff. Cultures may even differ strongly within these groups for example between academic staff and faculty from different disciplines and fields. Alongside these diverse cultural contexts there can exist a problem of language, with diverse and contrasting terminology being used to describe the same phenomenon within different cultural contexts. It is therefore important that a globally useful framework is applicable and usable by people across these various cultural divides.

In this chapter the authors propose a framework and methodology for the development of Living Labs within HEIs; and present a shared living lab framework to achieve this, that will be open sourced and usable across a global divide. What distinguishes this approach from ‘sustainability’ research already taking place at our universities is the opportunity at one end to recognize and identify sustainability challenges at the campus to city scale that can catalyse applied research. On the back end, living lab models predominantly need to engage the user base, which leads to a quick feedback loop. Successful projects may therefore enable universities to advance sustainability more rapidly on their campuses. This alone warrants deeper research.

2 Developing the Framework

2.1 A Transformational Process Benefitting from Existing Ecosystems

Fazey et al. (2018) state that "The most critical question for climate research is no longer about the problem, but about how to facilitate the transformative changes necessary to avoid catastrophic climate-induced change. Addressing this question, however, will require massive upscaling of research that can rapidly enhance learning about transformations." However, it is not just climate change, which society faces as a major issue relating to our environmental, social, and economic sustainability; and similar levels of research and transformations are needed across a much wider range of issues in our move towards a more sustainable future. Living Labs can be part of the solution to these problems of upscaling research and enabling transformation with many authors claiming that the most effective Living Labs are those making use of an actual existing environment with its own "ecosystem" of physical environment, structures, individuals, history, culture, weather, etc. - perfectly exemplified by the university campus.

Dealing with the necessary rate and scale of the required societal transformations for a more sustainable future, requires a transdisciplinary approach, integrating researchers and users (Baumgärtner et al. 2008; Boserup 2010; Farley et al. 2010; Frame and Brown 2008; Kajikawa 2008; Kauffman 2009; Komiyama and Takeuchi 2006; Schneidewind 2010; Steinfeld and Mino 2009; Vandermeulen and Van Huylenbroeck 2008; Weinstein 2010). Jahn et al. (2012) defines Transdisciplinarity as "… a critical and self-reflexive research approach that relates societal with scientific problems; it produces new knowledge by integrating different scientific and extra-scientific sights; its aim is to contribute to both societal and scientific progress; …". For a Campus Living Lab this means that it should consider those critical and self-reflexive research approaches in order to conduct highly adaptive, reflexive, collaborative and impact-oriented research to enhance capacity to respond to the climate and other sustainability challenges (Fazey et al. 2018). It is these ideas, which underpin the development of the Living Lab learning system framework outlined in this chapter.

2.2 Requirements for a Valuable Framework

We have built this framework on a number of underlying assumptions of what our universities have in common and share across continents: People, organisational structures, place, costs, data and the desire to contribute to a more sustainable future, locally and globally. The Living Lab framework presented, that we call a 'Campus as Living Lab' learning system, aims to be useful in the following ways:

1. to support the planning stages of a campus-based sustainability project, to ensure that the educational, research and wider community benefits are maximised;
2. to support the monitoring of such projects, ensuring opportunities for benefits are fully explored throughout;
3. to support the reflection and internal learning of a project once completed, and ascertain ways to develop further impact;
4. as a tool to improve engagement with diverse stakeholders in the unique local environment. This methodology and framework is unique to the context of HEIs, because of their breadth of stakeholders through their combined education, research and wider community engagement missions as well as their extensive estate; and
5. as a way of disseminating good practice across the global sustainability HEI community, allowing people from across the world to easily access detailed case studies of processes, practices and products to inform their own work on sustainable practices in their own HEIs.

The framework is also focused specifically on using improvements in the sustainable practices of the campus environment and operations itself as the 'living lab', meaning that the HEI's community of staff and students comprises the various roles of the researchers and those being researched, as well as the educators and those being educated. However, this framework could also be modified for use in large organisations interested in improving their sustainability practices, educating their stakeholders, and learning and reflecting on the processes and impacts of changes in their practices. This framework could also be adapted within an HEI setting, where university researchers work within the local, or wider, community to improve sustainable practices external to the HEI, and use this research to feed into their own campus developments, and educational programmes and approaches. The localization and utilization of this framework is up to the practitioner on the ground to interpret, test, test again and apply, reflect, and rework until it is successful for their own context.

2.3 A Co-creation Process

The framework integrates knowledge and experience of developing, and researching Living Labs within university campus environments. In developing the framework, the authors have studied literature about Living Labs (Gross 2005; Liedtke et al. 2012; Brandt 2013; König and Evans 2013; Schneidewind 2014; Trencher et al. 2014; Evans 2015; Gross 2015; Schäpke et al. 2015; Voytenko et al. 2015) literature about transition research and transformation science (Sharp 2002; Cortese 2003; Koester et al. 2006; Lozano 2006; Ferrer-Balas et al. 2008; Pohl and Hadorn 2008; Loorbach and Rotmans 2010; Dunphy et al. 2014; Wagner and Grunwald 2015) and reports created by organisations based on best practices and case studies (Lozano 2006; Lang et al. 2012; Scholz and Steiner 2015a, b; Botero et al. 2017). An important element in the creation of this framework were the feed forward and feedback processes within the international HEI community.

The need for a framework such as the one presented was established in 2016, through the ISCN, the International Sustainable Campus Network—a global network aimed at supporting leading colleges, universities, and corporate campuses in the exchange of information, ideas, and best practices for achieving sustainable campus operations and integrating sustainability in research and teaching. For many years the ISCN has hosted a working group on 'Integrating Research, Teaching and Facilities', and in 2016 the group determined that a more methodological approach could be valuable to maximise the potential of this integrative approach. The co-authors from MIT, TUD, Keele, Hokkaido and ETH Zurich, entered into a process to develop a potential new framing for discussion in the ISCN Vancouver conference in 2017.

From the onset, it was decided *not* to make a framework and then to present it as a fixed 'take-it-or-leave-it' product, but rather to *share the initial discussions for a framework and enter into a co-creation process*, bringing in feedback and involvement of the ISCN participants. This approach was valued by the 30+ participants, who agreed on the desirability of a framework and methodology, which integrated stakeholder involvement, provided support for the management of Living Labs, and enabled the connecting and sharing between peers. Based on these inputs, it was decided to move on, and attempt to build a more descriptive framework, with the help of more HEIs.

An initial framework was built using initial thinking (Verhoef et al. 2017) and the Vancouver working group report (Vancouver 2017), taking the strengths from the various other Living Labs Methodologies, for example, AMS Institute (Steen et al. 2017), ENoLL (Malmberg and Vaittinen 2017; Bodi et al. 2015), Keyson (2017), Social Labs (Hassan 2014), and Rathenau Institute (Maas 2017). From these, the requirements for seven categories of data collection were extracted, referred to as: General, Scope, Participants and Co-creators, Organisations, Outcomes, Impact, and Reflection and Review. These are currently in the process of being further defined and parameterized. The Market Impact Assessment Methodology developed by New-Energy-Works for the European Commission was used to subdivide the impact category (Verhoef et al. 2004).

3 Description of the Framework

3.1 The Seven Data Collection Categories

The proposed framework is meant to lead to the development of a database to collect key data about a Living Lab. It is designed to be a supportive instrument over the whole lifetime of a Living Lab—from initial planning stages, through monitoring phases, through to its final closure and reflection on the lessons learned. The seven categories for data collection cover all of the different stages of the Living Lab, and allow monitoring on whether outcomes and impacts set out in the initial stages have been met, and how partnerships, participants, co-creators and organisational structures have evolved. The seven data collection categories are:

1. ***General***: a summary of the Living Lab location, key contacts, status, timelines and budget.
2. ***Scope***: the problem being addressed, historical details to the problem, the context, and the key sustainability 'theme' being addressed.
3. ***Participants and Co-creators***: different stakeholders and ways in which they are engaged.
4. ***Organisation***: leading organisations, partnerships, potential risks.
5. ***Outcomes***: anticipated (and actual) sustainability outcomes in relation to the problem being addressed, as well as anticipated (and actual) educational, research and engagement outcomes.
6. ***Impact***: wider impacts outside of the Living Lab boundaries.
7. ***Reflection and Review***: evaluation of the Living Lab products and processes (Fig. 1).

Through completing the data required in the planning stages of a Living Lab using this proposed framework, the user will gain guidance on the information needed to try and think through the different aspects to maximise the benefit of the Living Lab, and to enable learning from the Living Lab to be learnt from internally and shared externally.

The 'General' category contains contact information and data about the project management. The 'Scope' category guides the framework user through the key elements of the Living Lab. Inputs need to be precise and clear to all stakeholders who may be involved, clearly outlining the specific topic or problem being addressed by the Living Lab, the issues aiming to be addressed, or the area of innovation.

Category three, 'Participants and co-creators' requires the framework user to consider the necessary data about the methodology of the Living Lab, with specific consideration of the different stakeholders, therefore providing a clear picture of the outreach and the communication requirements of the Living Lab as well as the interaction complexity. This leads to category four 'Organisation', where the focus is on the organisational structure of the Living Lab.

The 'Outcomes' and 'Impact' categories allows the framework user to outline from the start the desired and predicted outcomes and wider impact of the project. With the increased visibility of the United Nation's Sustainable Development Goals (SDGs), and the move for many organisations to audit their activity against the SDGs, it may be desirable to link the 'Outcomes' and 'Impact' categories directly to the objectives of UN SDGs. For example, outcomes of Living Lab projects can refer to reduction in greenhouse gases, reduction of pollution to water bodies or the atmosphere, improved health, improved working conditions, and improved nutrition, which all have close relation to the SDGs. Outcomes can also refer to concrete physical changes in the University estate and its environment, changes in operations, processes or decision making, or educational outcomes for the campus community

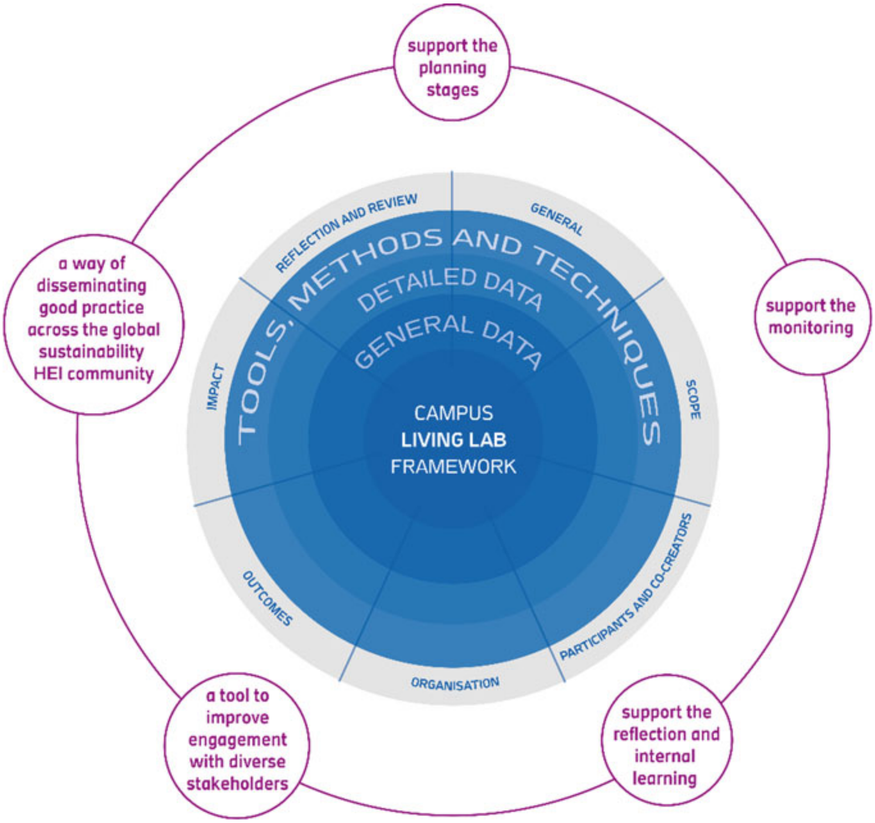

Fig. 1 Campus as living lab framework design with its seven categories and five potential values and three levels of detailing and application. Copyright the authors

and society. The 'Impact' section depicts potential amplification avenues and effects, beyond the initial boundaries of the Living Lab.

These 'Outcomes' and 'Impacts' sections are also key in the monitoring phases of the project, to assist in monitoring how close the project is to the original anticipated outcomes and impact, and therefore any changes that may need to be put in place to ensure that the original desired outcomes are achieved. The insights, of this monitoring phase, and final reflections on the processes and products (outcomes and impacts) will be collected through category seven 'Reflection and Review'. This is the only part of the framework that is not completed as part of the initial planning stage, unless it is to be used to outline the documentation, or reflection processes, that are required to be collected throughout the Living Lab process, to feed into the final reflection process (Fig. 2).

General	Scope (Idea)	Participants & Co-Creators	Organization
LEVEL 1 **Living Lab Information** Name ……….. Organisation ……….. City ……….. State ……….. Website ……….. **Personal Information (Projectmanager)** Name ……….. Email Address ……….. Phone ………..	LEVEL 1 **Brief Description** Problems/Issues being addressed …………………………… …………………………… …………………………… Story Behind the Project …………………………… …………………………… …………………………… Initiator …………………………… …………………………… ……………………………	LEVEL 1 **Users Defined in advance?** ○ yes ○ no **Type & number of participants from University Community** ○ students ○ academic staff ○ non-academic staff ○ socio-political groups (eg.: members of unions, members of campus,…) ○ informal groups (eg.: all cyclists; etc.) ○ alumni	LEVEL 1 **Lead** ○ facility services ○ faculty management ○ scientists ○ students group ○ other …. **Other organisations** ○ companies ○ authorities local ○ authorities regional ○ authorities national ○ other ……………
LEVEL 2 **Status** ○ in preparation ○ ongoing ○ completed **Project Timeline** Start year ……….. Finish year ……….. **Budget (Eur/ $)** …………………… **Date of entry** ……… **Photos of Projects**	LEVEL 2 **Goal of innovation (total 100%):** Education / learning ……………….% Research / Innovation ……………….% University Sustainability ……………….% **Living Lab Characteristics** ○ Topic of the Living Lab ○ Problems/ Issues being addressed ○ Participants/ Stakeholders ○ How are they addressed / description of the way the joint Living Lab communicates and defines research questions, develops tasks, products, services, processes etc. ○ Type of Living Lab (multi-, inter-, trans-disciplinar) ○ How it developed, what was the initial core point, who is the driving force and	LEVEL 2 **Type & number of participants from Civil Society** ○ NGOs ○ collaborative platforms (ad-hoc social media groups; etc.) ○ informal groups (eg.: local community; cyclists) ○ other **Type & number of participants from Industry** ○ startups ○ SMEs ○ large or multi-national companies **How many users:** ○ students …………… ○ staff …………… ○ scientists …………… ○ stakeholders ……………	LEVEL 2 **Living Lab team leads** ○ students ○ academic staff ○ non-academic staff ○ socio-political groups (eg.: members of unions, members of campus committees; etc.) ○ informal groups (eg.: all cyclists; etc.) **Organisation Layer** ○ Bottom- Up (eg.: admin staff, students, class etc.) ○ Middle-Out (eg.: operation managers; chairs; etc.) ○ Top-Down (eg.: senior staff, direction; board, etc.)

Fig. 2 Campus as living lab parameter list, work in progress, version 1.0, depicting the overall category and detailing for general, scope, user interaction and organisation. Copyright the authors

3.2 *Three Levels of Detail and Three Stages of Use*

The framework is designed to support the implementation and monitoring of an effective Living Lab learning system, through its seven categories of data collection. However, depending on the stage of the project or the user of the framework, they may choose to engage with the framework on three different levels, and at three different stages, the planning, monitoring, and review stages. These different levels and stages are still under development, but recognize the various different needs of different user groups, and how this might change throughout the lifetime of the project. An outline of the three different Levels at which users can engage is given below:

- Level 1: *Overall data* and basic information about the Living Lab. This assists in the initial description of the Living Lab, including outlining of the 'problem' being addressed and the anticipated broad outcomes and user groups. This Level relates to the early part of Stage 1, the Planning stage.
- Level 2: *Detailed data*. This refers to the collection of more precise information and parameters for the project, including specific outcome metrics, and anticipated numbers from different stakeholder groups. This Level encourages more detailed planning (Stage 1—Planning), and also more detailed monitoring (Stage 2) and review (Stage 3), considering a greater range of questions and more detailed analysis.

– Level 3: T*he Living Lab 'toolbox'*. This Level refers to guidance provided within the framework as to the tools, methods and techniques that can support the setting up, running, communicating, monitoring, and reviewing of a Campus Living Lab with various stakeholders from inside and outside the university community.

3.3 Co-development of the Framework

Testing the tool in several universities and collecting data from diverse Campus Living Lab projects has shown that the framework methodology can help guide and illuminate critical key points in the planning, monitoring and reflection stages of a Living Lab. However, the wording and naming of certain categories, headlines or participant and co-creator groups varies from country to country. Therefore, it is necessary to modify and improve the tool iteratively based on feedback loops of users from around the world, and working in different contexts, and to develop based on those findings a standard glossary for the definitions of words to facilitate wider use. Clearly in inputting data into the framework there is a balance to be had in terms of very minimalistic descriptions that may not provide enough detail to effectively inform people outside of the project, and very wordy descriptions which will reduce the likelihood that others will read through all of the information.

Users of the framework need to bear in mind the need for clarity and precision, and have in mind the need for the data inputted to be usable by a wide range of different stakeholders from many different cultural contexts. A shared framework and communication method will prevent too much space for different interpretations of Living Lab projects and make it possible to use the framework to publish project details on websites, databases, papers or press articles and to share learning between peers. Through the collection of these data and gathering them in an international platform it will be possible to search for universities or Living Labs dealing with similar issues and tasks, to use the framework as a source of learning between institutions as well as a starting point for conversations between institutions, enabling greater progress towards sustainable development in HEIs, and strengthening the ability of Living Labs to act as agents of change within their institutions and in society.

4 Discussion

4.1 Living Labs Strengthening University Work Towards UN SDGs

The Campus as Living Lab learning system was created based on Living Lab literature, participatory workshops and expert discussion. The learning system has seven key categories for data collection (referred to as general, scope, organisation, participants and co-creators, outcomes, impact in the world and reflection and review).

The scope, outcomes and impact of Living Labs can relate closely to one or more of the UN SDGs. It should be noted that the UN SDGs are large-scale and long-term goals, where it is easy to think that single projects cannot visibly contribute. Yet small scale or incremental changes both contribute to the whole and can be scaled up to include more of an organisation, more organisations or similar projects in different organisations or contexts. This is particularly the case, as University campuses and their communities are significant in terms of urban and global built area and population, as well as in educating society's future leaders and global decision makers.

In 2015, there were 18,500 HEIs worldwide, with 212 million students and 13 million teachers (EdStats 2018) and they are estimated to be responsible for 1.4% of global CO_2 emissions (Verhoef 2018). Therefore, universities have a responsibility to both reduce their negative impacts, improve their positive impacts, as well as educate everyone on and around the campus to be able to view the world through a sustainability lens, and be beacons of a move towards a more sustainable future.

4.2 Creating Value

The Living Lab framework presented in this chapter, aims to create value to University's sustainability efforts in the following five ways:

1. to support the planning stages of campus-based sustainability projects, to ensure that the educational, research and wider community benefits are maximised;
2. to support the monitoring of such projects, ensuring opportunities for benefits are fully explored throughout;
3. to support the reflection and internal learning of a project once completed, and ascertain ways to develop further impact;
4. as a tool to improve engagement and communication with diverse stakeholders;
5. as a way of disseminating good practice across the global sustainability HEI community, allowing people from across the world to easily access detailed case studies of processes, practices and products to inform their own work on sustainable practices in their own HEIs.

Preliminary tests at the Delft University of Technology and the University of Applied Sciences Stuttgart show that the framework aids in highlighting issues covered, issues discarded and issues 'forgotten', and hence highlight the potential of the framework in delivering to both 1 and 2 of the 'uses' of the framework highlighted above. However, these preliminary tests also highlighted that many stakeholders are interested in the *outcomes* the framework delivers rather than the *process*. They value the idea that a trustworthy actor (e.g. the Sustainability Office) puts its knowledge, weight and confidence in the framework.

The *fourth* use of the framework above (engagement and communication with stakeholders) demonstrates how a more process-oriented approach can help in the implementation of a Living lab and in overcoming common barriers. The steps in starting that process are (1) recognising the envisioned (global) impact, (2) attaining common understanding of and respect for the various outcomes, (3) designing the work space with all stakeholders needs in mind (time, location, and resources). The elements for running an effective Living Lab require a holistic approach and effective connection and communication with all relevant users, researchers, educators and operations staff.

To ensure the *fifth* 'use' of this framework (peer-peer learning) requires the framework to include a feedback and fast (practical) learning system, preferably within existing practitioner networks within HEIs such as the ISCN. The system should facilitate open and non-anonymous peer reviewing. It is envisaged that the framework becomes a peer-reviewed system whereby case studies are entered and peer reviewed, and enter into an open access database.

5 Conclusion and Next Steps

This paper describes a living, shared framework and methodology, the 'Campus as Living Lab' learning system, created through global participatory workshops and Living Lab literature, aimed at supporting universities and their Sustainability (Coordinating) Offices in the development and monitoring of Living Lab projects. The framework includes seven categories of supportive data collection, three levels of detail to meet different requirements of potential users, and three stages of use.

The Living Lab framework presented in this chapter, aims to create value and help universities maximise the benefit of Living Lab projects within an institution, support monitoring, reflection and learning from projects, and facilitate communication with stakeholders, and the sharing of practices and learning between peers across the globe. As a living shared, framework and learning system, the framework will adapt and develop over time and within different contexts. To provide feedback and fast (practical) learning from users, the system will be further developed to facilitate transparent peer reviewing.

Development of this framework has raised a number of questions with scope for further in-depth and detailed investigations in relation to the design and operation of Living Labs. These key areas of questions may be categorized as follows:

- campus data acquisition; tracking and analysis and managing risk;
- educational and research outcomes;
- solution design, applicability, scalability and culture.

Within the area of *campus data acquisition* questions arise around how data is collected and managed—how do we handle the real and perceived risks that come with greater transparency? How do we handle privacy issues that may exist in the accessibility of data sets? Can increasing data access, enhance transparency, and through enhanced transparency impact behaviours and decisions to ensure maximum sustainability benefits?

In the area of *educational and research outcomes* questions arise about how to use campus-based sustainability projects to maximise educational outcomes, for example how can we make 'invisible' sustainability improvements 'visible' and a source of learning for both the student and staff population, through what is referred to as the 'hidden' or 'subliminal' curriculum (Winter and Cotton 2012; Robinson and Madley 2017), and how do we engage the breadth of the research community?

Finally, in the area of *solution design, applicability, scalability and culture,* questions arise in how we encourage the replication and upscaling of the process, ensuring a culture which values incremental advances, and the replication of process, so that we are not all driven to design our own version of the wheel. Our framework can be seen as yet another approach. However, through its incremental, participatory and on-going development, we hope that this framework can be something that the global university community can own, develop, and apply within their own contexts to maximise the benefits to all stakeholders, as well as being used to share the stories of Living Labs and related scholarship in ways that make the research more accessible and in turn applicable, and ultimately help universities drive genuine and lasting change towards a more sustainable future.

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Nurturing the Seeds of Sustainability Governance: Rio+25 Brazilian Higher Education Institution Case Study

Ursula Maruyama, Patricia Prado, Aline Trigo and Jose Trigo

Abstract Once Brazil hosted United Nations Conference on Environment and Development in 1992 (UNCED, Rio Earth Summit), as well as Rio+20 Conference, the country has shown an important role in promoting United Nations Post-2015 Development Agenda. Brazilian innovations in terms of public policies are also regarded as contributions to economic, social and environmental dimensions in sustainable development integration. In this context, the Brazilian Ministry of Environment created the Environmental Agenda in Public Administration—'A3P'—to encourage public managers to incorporate sustainable principles enhancing institutions activities. In terms of sustainability, higher education can introduce new trends in the domains of education, research, and extension. However, understanding the Environmental Agenda in Public Administration requires a more careful analysis of information, stakeholder dynamics, public management and conflict of interest. To illustrate the debate, this chapter presents Cefet/RJ, a centennial higher education institution in Rio de Janeiro and discusses the implementation of its 'A3P' sustainable agenda in 2017, 25 years after Rio 92 Earth Summit. Thus, Cefet/RJ Rio+25 integrates teaching, research and extension environmental projects. This scenario represents a set of initiatives regarding the Sustainable Development Goals (SDGs) to assess public governance focusing on higher education. This chapter aims to be

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useful to those who are interested in governmental and sustainable developmental issues.

Keywords Sustainable development goals · A3P · Higher education institution · Environmental governance · Sustainability

1 Environmental Agenda: General Scenario

Recent increase in social upheavals around the globe, particularly in developing countries, has become an unequivocal evidence of dissatisfaction. Much of this relates to a bitter disappointment with capitalism and its production modes, which generates an unequal income distribution and high level of social injustices. In an increasingly globalized world, environmental impacts raises inequalities in society.

During the second half of the twentieth century, globalization has increased the integration of economies and societies, especially goods and services, financial markets and information. However, globalization also means a growing integration of transnational corporations, in a context of free trade and 'invisible hands', in which large corporations can operate (and exploit) in many different countries at the same time based on variations in local conditions (Granja 2008). Reduced trade barriers and better transportation and logistics, for example, have accelerated deforestation in South America by 'shortening the distances' between urban consumers and producers in distant agricultural lands. Above all, globalization privileges a smaller number of groups, which concentrate knowledge, science, new technologies and critical goods such as information.

There is an urgent need to perceive the environment in a different perspective, with a "passage from an isolated and loser environment to another situation, where the environment aligns with economics, social equity and inclusion" (Camargo 2012, p. 50). The Conference on Sustainable Development, or Rio+20 as it is widely known, has left a legacy about the possibilities of a sustainable reality and the necessary roles and commitments to achieve this reality. In line with Sanson (2014) and with the need to make theory into practice, changing this situation requires going beyond traditional static models, bringing greater coherence to arguments, and involving all social actors in a debate characterized by unequal power relationships.

The United Nations (UN) has recommended building transparent and monitored management through clear indicators and targets for sustainable development during Rio+20. In practice, there must be more participatory planning (Camargo 2012). Unfortunately, more than twenty years after the Second World Conference on Environment and Development, which brought together over one hundred Heads of State in Rio de Janeiro in 1992 (ECO 92), there was no significant progress. Once again, the sustainable development challenge remained in the social 'agenda'. In some places, there were not even institutional conditions to implement an environmental policy due to the lack of an active State to act as 'protagonist'. It is expected that the State adopt a regulatory role and encourage the process of change, bringing together all

Table 1 Sustainable development goals

Goal 1. End poverty in all its forms everywhere **Goal 2**. End hunger, achieve food security and improved nutrition and promote sustainable agriculture **Goal 3**. Ensure healthy lives and promote well-being for all at all ages **Goal 4**. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all **Goal 5**. Achieve gender equality and empower all women and girls **Goal 6**. Ensure availability and sustainable management of water and sanitation for all **Goal 7**. Ensure access to affordable, reliable, sustainable and modern energy for all **Goal 8**. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all **Goal 9**. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	**Goal 10**. Reduce inequality within and among countries **Goal 11**. Make cities and human settlements inclusive, safe, resilient and sustainable **Goal 12**. Ensure sustainable consumption and production patterns **Goal 13**. Take urgent action to combat climate change and its impacts **Goal 14**. Conserve and sustainably use the oceans, seas and marine resources for sustainable development **Goal 15**. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss **Goal 16**. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels **Goal 17**. Strengthen the means of implementation and revitalize the global partnership for sustainable development

Source United Nations (2015)

sectors of the society and providing a suitable environment for development amidst this troubled scenario.

During the time between Eco 92 and Rio+20, at least a positive change has emerged with the raise in the awareness and practice of sustainability by companies: large international conventions, protocols and agreements were held. In 2000, the UN launched a set of targets for government action to address inequality, poverty and endemics. The Millennium Development Goals (MDGs) were supposed to be met by 2015. By this time, during the Sustainable Development Summit, the UN recognized there was a need to broaden the scope of the objectives, incorporating a more holistic view about developmental problems. The Sustainable Development Goals (SDGs) were developed, then, including new areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice, among other priorities, and proposed in an agenda established by 193 UN Member States Agenda (United Nations 2015).

The '2030 Agenda for Sustainable Development' is a plan of action that sets 17 goals and 169 targets around areas, which are considered of critical importance for humanity and the planet: people, planet, prosperity, peace and partnership. The 17 SDGs are presented in Table 1.

The implementation of SDGs is a challenge that calls for active participation of different social actors in sharing the responsibility of actions, including governments, non-governmental organizations (NGOs), civil society and companies. Despite their global nature and universal applicability, the SDGs dialogue with regional and local policies and actions, requiring several levels of participation.

All UN who signed the Paris Agreement at the COP21 in Paris (December 2015) have committed themselves to important initiatives within the SDGs. They agreed to discuss, elaborate and propose public policies, new partnerships and strategies aimed at promoting more sustainable patterns of production and consumption. According to Grossi (2017, p. 53) “stronger international cooperation involving understandings of effective mechanisms to promote technological innovation and technology transfer is a prerequisite for efforts universalization”. Brazil is one of the countries who signed the Paris Agreement and, therefore, must commit to the achievement of the SDGs. As one of the responses, the Brazilian Ministry of Environment (MMA in the Portuguese language acronym) created the Environmental Agenda in Public Administration or, simply, ‘A3P’. This program aims to stimulate public agencies in Brazil to implement sustainability practices and focuses on the:

> […] sensitization of public managers to socio-environmental issues, encouraging them to incorporate principles and criteria of environmental management into the routines of public administration, through: the promotion of actions that demonstrate the rational use of natural resources and public goods; adequate waste management; quality of life in the work environment; minimum environmental impact and maximum comfort for users in construction, sustainable bidding/green procurement, and the process of continuous training of the public employees (MMA 2009, p. 9).

Thirteen years after the creation of the ‘A3P’ program, in this same spirit, Normative Instruction n. 10 of 2012 established rules for the elaboration of Sustainable Logistics Management Plan. This plan allows Brazilian public institutions to establish practices of sustainability and rationalization of expenses and processes (MPOG 2012). According to Decree 7746/2012, which established the obligation of all entities of the Federal Public Administration, autarchic, foundational and state-owned companies to prepare their Sustainable Logistics Management Plans, the following guidelines of sustainability should be observed:

I—Adopt procedures that cause less impact on natural resources;
II—Give preference to materials, technologies and raw materials of local origin;
III—Use natural resources such as water and energy more efficiently;
IV—Provide greater generation of jobs, preferably with local workforce;
V—Provide longer life and lower cost of maintenance of the goods and the work;
VI—Use technological innovations that reduce the pressure on natural resources; and
VII—Make use of the resources that have environmentally regular origin of the natural resources used in the goods, services and works (Brasil 2012, Art. 4).

Environmental management perceives a new thinking that needs to be accompanied by changes in perceptions and new practices at the micro level: from expansion to conservation, from quantity to quality, from domination to partnership, from reactive management to pro-active management. It is based on the premise that public administration should prioritize transparency, honesty and competence to seek good operational results focused on sustainability.

One of the reasons for the recognition of case study as a research method is that researchers were becoming more concerned about the limitations of quantitative methods in providing holistic and in-depth explanations of the social problems in question. Through case study methods, a researcher is able to go beyond quantitative statistical results and understand the behavioural conditions through the actor's perspective (Yin 2009).

Within this context, this chapter presents the case study of a Brazilian Higher Education Institution, Cefet/RJ, and discusses its relevance as an inducer of changes for the establishment of a new sustainability model incorporated in the dimensions of research, teaching and extension.

In methodological terms, "a research investigates the world in which man lives" (Chizzotti 2006, p. 11), but in order to be robust in its trajectory and in its approach to its object of study, methodological procedures are required. Considering the objectives, this is an exploratory research, which aims to provide a wider range of information about the phenomenon studied (Carrancho 2005). For its procedures, after a literature review, this investigation analyzes the case study of Celso Suckow Federal Center of Technological Education of Fonseca (Cefet/RJ), a Brazilian public Higher Education Institution (Gil 2012).

Cefet/RJ is a relevant case in the Brazilian context, as in January 2018, it has joined 'A3P'—the Environmental Agenda in Public Administration (Brasil 2018)—and created its Institutional Environmental Sustainability Committee. This committee is an advisory collegiate body composed by 25 employees, collaborating with the Environmental Sustainability Institutional Strategy Division (DISAI) for the development of institutional environmental policies and actions of Cefet/RJ, promoting the awareness of an anti-waste culture and the coherent use of environmental resources and public goods.

2 Sustainability in Higher Education

Higher Education Institutions (HEI) have a relevant role in the dissemination of sustainability, especially when incorporating environmental values and practices, both in the disciplines taught and in the administration of their physical structures (Feres and Antunes 2007). How students learn to think about sustainability will influence their actions as local and global citizens (Moore 2005).

Increasingly, higher education institutions are driven to play a leading role in Education for sustainability:

- High concentration of critical mass, creativity and technological potential that can be channeled into environmental innovations. The main asset present at universities is knowledge, and its organization is focused on the production, transmission and diffusion of it.

- They form future professionals, gatekeepers (leaders of opinion) and potential leaders of social institutions.
- They can offer a practical testimony of what is preached in teaching, research and university extension. University should practice what it teaches, to set an example even on the challenges of environmental change.
- Students consider that studying at a university whose campus has environmental responsibility and commitment to sustainability is a positive differential in their formation (Layrargues 2011, p. 3).

The first statement that referred to sustainability in higher education was the Stockholm Declaration (1972), which established the need to implement environmental education already in primary school through adulthood, incorporating a sense of responsibility for improvement of the environment for people, businesses and the community (*Organization des nations unies pour l'education*, *La science et la culture*, 1973 *apud* Madeira 2008).

In 1992, Agenda 21 chapter entitled "Education, Training and Public Awareness" highlighted current priorities of higher education on sustainability issues: development of transdisciplinary curricula, scientific research on sustainability and the formation of a network of organizations and individuals involved in promoting environmental awareness (United Nations Department of economic and social affairs, Division for sustainable development, 2007 *apud* Madeira 2008).

Sustainable actions that most appear in Environmental Management System (EMS) in a teaching institution are water consumption control (and its reuse) and selective waste collection program, followed by students training and sensitization. Although several initiatives dedicated to pursue eco-efficiency in energy, waste management, building design and purchasing, perverse subsidies and hidden cost make sustainability hard to achieve (Calder and Clugston 2003).

However, Ribeiro et al. (2005) argue that the existence of barriers to a possible implementation of environmental policies is very common, among which the following can be highlighted: (a) lack of information on sustainable development practices of society; (b) non-valuation of environment by several employees; and (c) non-perception of university as a potential source of pollution.

Transforming our educational systems to support sustainable development is a challenge that involves all levels of education—policy, curriculum and pedagogical practice (Raus and Falkenberg 2014).

More recently, during Rio+20 Conference (UN, 2012), the HEI agreement "Sustainable development and education", which has signed a commitment to incorporate the premises of Sustainable Development in teaching, research and its own management and organizational activities. This action inspired the creation of the "Declaration for Higher Education Institutions", aiming to guide the "Principles for Responsible Management Education" (PRME) initiative.

The document discussed the relevance of creating and maintaining a curriculum in which teaches and encourages the incorporation of Sustainable Development principles, as well as fostering scientific research seeking development, adaptation, diffusion and transfer of knowledge, emphasis on research based on technologies. In a complementary way, guidelines were also drawn up for the incorporation of good practices in daily operations in campuses. The heart of this document suggests:

> (*i*) reducing ecological footprint through energy, water and resources efficiency in buildings and facilities; (*ii*) adoption of sustainable purchasing practices in supply chain and catering services; (*iii*) providing sustainable mobility options for students and teachers; (*iv*) adoption of effective programs for waste minimization, recycling and reuse, and (*v*) promoting more sustainable lifestyles (UN, 2012).

Therefore, sustainable higher education institution is one that demonstrates to students how should one understand environmental degradation, as well as stimulate to seek environmentally sustainable technological solutions and practices while sensitizing them to social injustices (Madeira 2008). On the other hand, according to Avila et al. (2017), when a university seeks to implement sustainability initiatives as part of its daily activities, a set of barriers are encountered, which need to be addressed if the proposed activities are to yield the expected benefits.

3 Brazilian Case Study: Cefet/RJ

Celso Suckow da Fonseca Federal Center of Technological Education (Cefet/RJ) is an autonomous institution of special regime linked to the Ministry of Education (MEC), created by Law 6545 (June 30, 1978). Cefet/RJ contributed to human, scientific and technological training of professionals in the state of Rio de Janeiro.

The purpose of Cefet/RJ is to qualify professionals in technological education, at different levels and modalities of teaching, by various sectors of economy, as well as perform applied research and promote technological development of new processes, products and services, in close coordination with productive sectors and society, especially at local and regional levels, providing mechanisms for continuing education (Brasil 2005).

Since the expansion of Federal Network of Technical and Technological Education, Maracanã campus, located in Rio de Janeiro city, and other seven campuses spread around Rio de Janeiro state: Angra dos Reis, Itaguaí, Maria da Graça, Nova Friburgo, Nova Iguaçu, Petrópolis and Valença (Cefet/RJ 2017).

Cefet/RJ offers technical courses integrated to secondary, post-secondary, technological, undergraduate and post-graduate courses *lato* sensu and *stricto* sensu (masters and doctorate degree), both local and distance modalities. Given the diversity of teaching levels in Cefet/RJ, it is important to observe at all levels the three dimensions that involve educational process in this Center—teaching, research and extension—when constructing a project aimed at the development of skills and abilities of the human being (Cefet/RJ 2017).

It is also necessary to understand what refers to indissociability attributed to teaching, research and extension pointed out in the Institutional Pedagogical Project of Cefet/RJ (2010b), inasmuch as:

– teaching must be associated with extension, in a contextualized formation in contemporary social issues;
– research teaching aims competences development that aim to introduce students to basic forms of research, which, aiming at generating knowledge, providing subsidies for teaching activity itself;
– research, observing the social context, can produce intervention tools, as well as the extension can attend to those realities known through research.

Therefore, educational institution must be committed to a training that, by knowledge excellence, integral formation, responsible citizenship to sustainable environment, becoming aware of collective subjects and social accountability. Thus, Cefet/RJ main initiatives bring together all educational institution players, presented to provide adequate environment for sustainable reality, aligned with Global Objectives for Sustainable Development (2015) and the Declaration for Higher Education Institutions, emerged during Rio+20.

4 Teaching Environmental Agenda

Because it is everyone's responsibility, Environmental Education has become a crosscutting theme, a concern for all, from schools to universities and from the entire community where the individual is inserted. Henceforth, it gives people a critical and global understanding of the environment. This becomes the key to elucidating values and developing attitudes that allow us to adopt a critical and participative position on issues related to conservation and the adequate use of natural resources, with a view to improving the quality of life, eliminating extreme poverty and unbridled consumerism (Brasil 2002, p. 103).

Wiek et al. (2011) based on their study reflected the growing interest in developing a converging set of key competencies that can guide the design of programs and courses in sustainability, teaching and learning evaluations, training faculty and staff. As a learning organization (Senge 1990), Cefet/RJ deploys its purpose in Teaching within its basic characteristics:

> I - technological education, increasing incorporation of new methods and processes; II - priority action in technological area; III - theory with practice; IV - vertical articulation and integration of technological education at different levels and modalities of teaching, work, science and technology; V - offering undergraduate and post-graduate higher education in technological areas; VI - offering specialized training at all levels of education, taking into account trends in the productive sector and technological development; VII - conducting applied research; VIII - covering different levels and modalities of teaching, observing qualification required in each case; IX - shared use of laboratories and human resources by different levels and modalities of education; X - development of educational process that permanently favors the transformation of knowledge into goods and services, for the benefit of society; XI - flexible, rational organizational structure adapted to its peculiarities and objectives; XII - integration of educational actions with the expectations of society and the trends of the productive sector (Cefet/RJ 2010b).

Therefore, it is observed the presence of a common discipline—Environmental Sciences—in all undergraduate courses, which investigates and discusses the environmental issues that permeate the processes verified and contextualized in each higher course. The approach is made through an expository class and with presentation of case studies focused on the environmental issue. For example, in the Bachelor' Degree in Computer Science, the following objectives of the Environmental Sciences subject stand out:

> *General objective*: Enabling students to understand how the environmental theme is involved and inserted in the processes of Computer Science.
>
> *Specific objectives*: Understanding basic concepts about the Environment; Recognizing Man as one of the actors belonging to the Environment and understand its modifying action of natural environments; Recognizing sustainability aspects of projects; Identifying the main legal instruments in the environmental area; Obtaining an overview of the instruments of Public and Private Environmental Management; Identifying the practices of green information technology: Green IT (Cefet/RJ 2010a).

It is an opportunity to discuss the relevance of Environmental Education and reach not only the students but also the community in which students participate and their professional development. We must seek not only in this discipline, but in other already existing ones, focusing on development and reinforcement of academic contents that emphasize social, environmental, cultural, humanistic and citizen formation.

5 Sustainability Extension Activities

Extension activities developed at Cefet/RJ are differentiated, due to their origin and nature in the field of technological education. This action takes the form of programs, projects and courses, technological production and publication, using its own material and financial resources, as well as providing services (Cefet/RJ 2010a).

Actions stemming from student leadership led to programs "capable of individually and collectively putting scientific and technological knowledge acquired at the service of political, economic and social development in which they live", such as Formula SAE, CEFET Jr. Consultancy, while other programs promoted the "development of science and technology towards the perspective of human promotion", such as ENACTUS Cefet/RJ, as well as "participation in social movements", as a Citizen Team Program (Cefet/RJ 2010a).

During the year 2017, Cefet/RJ employees participated in actions to promote a culture of management and socio-environmental responsibility and enhancement of the institutional environment. The events, certified by Cefet/RJ Extension Board, became known as the "Institutional Environmental Sustainability Meetings".

The first meeting on June 28 was aimed at presenting and listening to ideas and proposals to be developed to meet the Environmental Agenda in Public Administration (A3P). The second, more specific, took place on November 29 exposed, shared

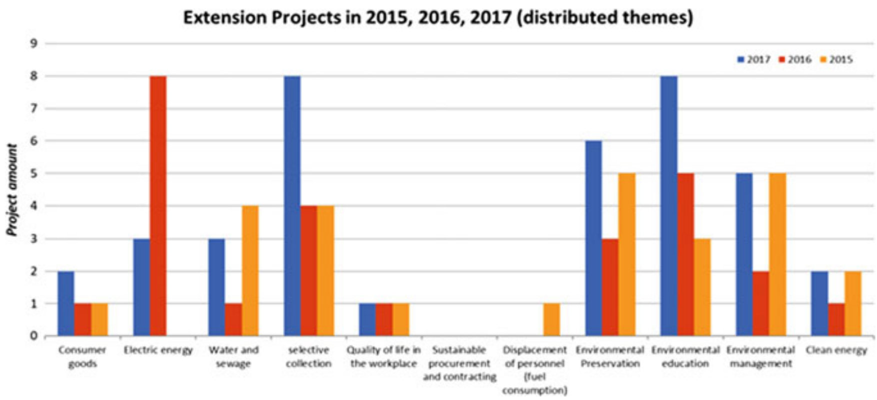

Fig. 1 Cefet/RJ extension projects overview *Source* DEAC Cefet/RJ (2017)

ideas and proposals for the rational use of water, based on water consumption diagnosis carried out at Maracanã campus. These two actions contributed to five themes considered in A3P (1-*rational use of natural resources and public goods*;2- *adequate waste management*;3- *quality of life in the work environment*;4- *awareness raising and training of employees*; 5- *sustainable biddings*), developed and applied in community, with Cefet's Senior Management support.

It was highlighted, from 2015 to 2017, the increase of extension projects in the development human promotion actions, which will lead to Cefet/RJ's internal and external environment sustainability. Figure 1 shows extension panorama in Cefet/RJ campuses, highlighting education and environmental preservation projects, besides selective collection.

By being directly involved in research and development of processes and technologies, Cefet/RJ Rio+25 presents more structured environmental management programs. It is worth mentioning, Cefet/RJ Recicla Program started in 2015, at Maracanã campus and, currently, expanded to other decentralized units of Cefet/RJ. The Program, through a Joint Selective Collection Commission, provides collecting service, separating and disposing of recyclable solid waste generated for waste collectors cooperative, followed by training and sensitization of students, servers and cleaning staff.

6 Fostering Green Technology Research

Cefet/RJ research activities are managed by Research and Post-Graduation Department, with the purpose of encouraging, systematizing, registering, managing and evaluating research activity institution at all levels of education. The Department's actions are carried out through the Coordination of Research and Technological

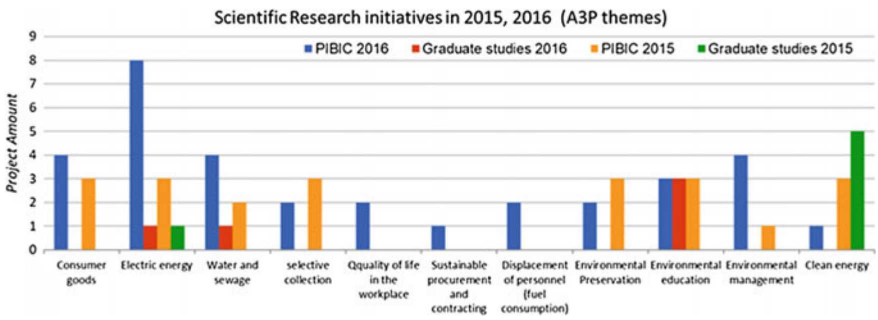

Fig. 2 Cefet/RJ scientific research projects overview *Source* DIPPG Cefet/RJ (2017)

Studies (COPET), which encourages scientific and technological research activities at Cefet/RJ (Cefet/RJ 2010b).

The National Council of Scientific and Technological Development (CNPq), an agency of the Ministry of Science, Technology, Innovations and Communications (MCTIC), has as main attributions to promote scientific and technological research and encourage the formation of Brazilian researchers. Cefet-RJ Research Groups are registered in CNPq Group Directory (Cefet/RJ 2010b), highlighting some sustainability themes such as:

– Environment and Energy Efficiency.
– Knowledge and Innovation Management.
– STS (Science Technology and Society) and Education.

Although much of Cefet/RJ scientific publication is focused on technological area, demonstrating research contribution to country socioeconomic development, arousing scientific vocation in future researchers training.

From 2015 to 2016, there was an increase in research projects based on sustainable development, guided by teachers with experience and expertise. Figure 2 shows Cefet/RJ research panorama, highlighting projects related to conservation and efficiency of electric energy (DIPPG Cefet/RJ 2017).

Subordinate to Research and Graduate Management Board and Research Department (DEPEQ), the Technological Innovation Center (NIT), whose objective is to manage the institutional policy to stimulate innovation and other forms of technological transfer, as well as governance of Cefet/RJ innovation system (Cefet/RJ 2010a).

7 Debating Cefet/RJ Sustainability Approach

Articulation between research, teaching and extension not only produces academic knowledge, but the formation of critical and conscious individuals. Notwithstanding activities of academic training are encouraged to promote student participation in initiatives for citizenship, social and environmental responsibility.

According to Disterheft et al. (2015) the concept of participation offers possibilities for transformative learning and critical thinking to take place in a more holistic manner. In addition, Leal Filho et al. (2015) argue that there is an increasing trend towards integrating sustainability as a transversal theme, rather than limiting it to specific parts of the curriculum, hence improving the potential for impact on all university students. In this sense, the authors understand universities are extremely important in the formal delivery of environmental education, yet they do not always provide effective environmental and sustainability learning.

In fact, the three dimensions (teaching, research and extension) involve educational process in Cefet/RJ are aligned with six fundamental points of sustainability, promote public awareness for environment preservation:

i. Sustainability approach in its multiple aspects, by means of curricular activity/discipline/obligatory interdisciplinary projects promoting the study of environmental legislation and knowledge on environmental management, according to baccalaureate courses, technology, specialization and extension training professionals working in the different areas.
ii. Promotion of research aiming instruments, methodologies and processes approach to environmental dimension applied to integrated curricula in different levels and modalities of education.
iii. Evaluative monitoring of environmental dimension incorporation in higher education to subsidize pedagogical projects improvement and elaboration of specific guidelines.
iv. Promotion of research and extension in environmental education.
v. Encouraging the promotion of educational materials as a reference for environmental education in diverse levels of education modalities.
vi. Participation in continuing education and teacher service processes (MEC 2017).

Is also worth mentioning the recent study presented by Leal Filho et al. (2018) which argue is not sufficient for university researchers to simply perform research: their outputs should be more widely communicated. In this context, a more dynamic approach from universities researchers towards using their findings to influence public discussions about climate change through media, policy networks and to interested communities is required.

However, the implementation of the program ‘A3P’ in Cefet/RJ did not always a smooth course. In line with the barriers identified by Ribeiro et al. (2005), Cefet/RJ also had to face some issues related to the non-valuation of environment by some of its staff/students and with the non-perception of the institution as a potential source of solid waste producer. For instance, many employees still don’t know what Public Administration Public Agenda means; financing environmental projects during economic crisis is an obstacle to managers; ‘departamentalism’ (beadledom, bureaucracy) is another issue. In order to minimize the impacts of these issues, Cefet/RJ had to improve its strategic management interpersonal skills as well as its environmental knowledge and information competencies.

8 Conclusions

Considering the profusion of environmental initiatives in the last decades and documents that emerge from their discussions, it is important to note that Higher Education Institutions play a central role in the tireless search for a fairer society that promotes environmental sustainability, through articulation of discussions about a less intensive development model in the use of natural resources and based on a more conscious consumption.

Some instruments must be implemented for elaboration and application of A3P in HEI, such as sustainable inventory of goods, practices of sustainability and rationalization of materials. These instruments allow searching for similar devices with less environmental impact, as well as identifying new purposes of these goods. It is also a way of thinking about waste reduction that is no longer generated from the moment that unsustainable materials are not purchased. While sustainable procurement effectively promotes environmental sustainability, disseminating the idea primarily among all applicants for goods and services, requirements from environmental sustainability criteria are found in bidding instruments. It also becomes an important indicator of social progress and innovation, responsibility to its citizens and demonstrates that its leaders are environmentally, socially and economically efficient as public managers.

Despite the debate about HEI dimensions adequacy to SDGs premises on university campuses, results are still far from ideal. Advances are necessary because their logic lies in the fact Higher Education Institutions, at its core, are fertile spaces for the emergence of ideas, followed by experimentation and discussion.

The main challenge has been shown to be the incorporation of attitudes that have convergence with sustainable practices and rationalization of expenses and processes, in operational day-to-day of university campuses. In fact, it is still evident the lack of concrete and efficient attitudes, as well as its integration and communication with community, seeking the rescue of values and the creation of new ones, attuned to a new sustainable and global ethics.

In this sense, understanding that this discussion does not end easily, we seek to contribute with reflections that, in synthesis, point to understanding that which results need to be perceived, not only in campuses now, but also in its long term, to naturalize university community commitment regarding their present environmental actions results as well as their impacts for the planet and next generations future.

Considering the abundance of initiatives presented by Cefet/RJ in the last three years, it should be emphasized the important role of educational institutions in formative character of exercising citizenship, in pursuing a more just society and promoting environmental sustainability, through the articulation of discussions about a less intensive development model in the use of natural resources and based on a more conscious consumption.

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The Transdisciplinary Living Lab Model (TDLL)

Dena Fam, Abby Mellick Lopes, Katie Ross and Alexandra Crosby

Abstract A Transdisciplinary Living Lab Model (TDLL) was developed in collaboration with two Australian Universities: the University of Technology Sydney and Western Sydney University. This TDLL model takes a transdisciplinary approach to learning while utilizing the university campus as a living laboratory. This chapter presents the processes used to create, and discusses the benefits of creating, a conducive environment for transdisciplinary learning on-campus in a project-based living lab.

Keywords Transdisciplinary living labs · Sustainable development goals · Leverage points · Systems thinking

The Transdisciplinary Living Lab case studies introduced in this chapter focused on food waste. In these TDLL experiences, a diverse range of students from many disciplines were mentored by course facilitators with expertise in transdisciplinary research and practice, to learn how to contribute their own disciplinary knowledge and expertise in transdisciplinary teams seeking to reduce food waste on campus. In addition, as a deliberate attempt to guide students to consider how local food practices impact on global systems, university system experts incorporated the Sustainable Development Goals (SDGs) into the TDLL activities. The students were

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also supported to communicate these insights in public, open and iterative platforms. In sum, the TDLL model was designed to facilitate students to:

(1) reflect critically on their embedded views of, roles in and impact on campus systems;
(2) develop skills in collaborative research to identify, bound, reflect and intervene to improve campus systems;
(3) justify the scientific and societal benefits of transdisciplinary outcomes for sustainable development.

The TDLL is systemically transformative in that it integrates undergraduate curriculum, university operations and research, priming the university to practically meet the SDGs. Utilizing campus infrastructure as a living environment for applied, collaborative learning not only advances sustainability on campus but prepares students with the skills, knowledge and enthusiasm to be active, engaged citizens, and to continue this work beyond their life at university.

1 Introduction: Inter-university Collaboration to Develop Innovative Sustainability Curriculum

This chapter details how two Australian universities have taken SDG 12 as a basis for developing a Transdisciplinary Living Lab (TDLL) to tackle the challenge of food waste production and management within the university campus and in the process, prepare design students to be active, engaged citizens beyond their life at university. The aim was to facilitate students to learn and practice design in a socially responsible manner, reflecting the rise of academic debate and teaching in the areas of social design, sustainable design, ethical design and design futures (Resnick 2016).

The chapter draws on two years of experience by the authors in developing a TDLL at the University of Technology Sydney and Western Sydney University where the on-campus food waste management system was used as the context for transdisciplinary learning by third year design students (from Fashion and Textiles, Visual Communication, and Product Design degrees). The following chapter will first provide a background context for the two universities involved in this project and how their commitment to the SDGs has resulted in the development of curriculum to sustainably manage food waste on-campus. We then summarise the problem of food waste globally, and how the issue is linked to SDG12, before presenting the three stages of design and delivery of the TDLL.

1.1 Background Context to Our Universities' Commitment to the SDGs

In 2016 and 2017 respectively, the University of Technology Sydney[1] and the Western Sydney University[2] signed a formal commitment to the SDGs and the associated 169 targets. The Commitment was organised by the Australia Pacific network[3] within the global Sustainable Development Solutions Network.[4] The network is a United Nations initiative which links and amplifies the role of Universities in achieving the SDGs. The University Commitment to the SDGs recognises the significant role of Universities in collaboratively realising the SDGs:

> Universities will have a vital role to play in addressing these critical global challenges and achieving the Sustainable Development Goals. Universities have a responsibility through their **teaching** to equip the next generation of leaders, innovators and thinkers to understand the global challenges facing the world and the role they can play in rising to meet these challenges. Through their **research and training** of research leaders, universities are at the forefront of finding sustainable social, economic, environmental and technical solutions to global problems. Finally, through their own **operations** universities can pioneer innovation and can set an example to other sectors and businesses (UTS 2016).

This Commitment underscores the importance of integrating educational goals with the everyday experience of campus life.

As discussed below, the TDLL integrates the three opportunities identified in the SDG Commitment (bolded above) into one collaborative learning experience. Combined, the TDLL and the communication of the results though the writing of this chapter contribute to the five agreements in the Commitment, namely that the universities involved will:

- "*support and promote the principles of the Sustainable Development Goals*
- *undertake research that provides solutions to sustainable development challenges*
- *provide the educational opportunity for our students to acquire the knowledge and skills needed to promote sustainable development*
- *contribute to the achievement of the Sustainable Development Goals by ensuring our campuses and major programs are environmentally sustainable and socially inclusive,*
- *report on our activities in support of the Sustainable Development Goals*" (UTS 2016).

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[1] www.uts.edu.au/research-and-teaching/our-research/institute-sustainable-futures/news/ending-poverty-protecting.

[2] www.westernsydney.edu.au/newscentre/news_centre/more_news_stories/western_sydney_university_commits_to_un_sustainable_development_goals_2030.

[3] http://ap-unsdsn.org/regional-initiatives/universities-sdgs/university-commitment-overview/.

[4] http://unsdsn.org.

1.2 The Food Waste Problem—Locally, Globally and Campus-Wide

The food waste issue is not only a problem at local and campus-wide scales. Globally it is estimated a third of all food produced for human consumption is lost or wasted which amounts to approximately 1.3 billion tons per year across the supply chain from agricultural production through to household consumption. The severity of the food waste problem is acknowledged in Sustainable Development Goal (SDG) 12 which focuses on "*responsible consumption and production*"[5] with the goal of:

- *substantially reducing waste generation through prevention, reduction, recycling and reuse and*
- *halving per capita global food waste at the retail and consumer levels and*
- *reducing food losses along production and supply chains, including post-harvest losses by 2030.*

Recognising the complex inter-relations between the goals, the mechanisms for addressing food waste also influence goals related to Zero Hunger (2); Good Health and Well-being (3); Clean Water and Sanitation (6); Sustainable Cities and Communities (11); and Climate Action (13).

Taking into consideration the significant issue of food waste at local and global scales, the University of Technology Sydney installed infrastructure and technology to manage 100% of the food waste produced on-campus through industry funding in 2015. In addition to the technological management of food waste, university-wide staff and student educational workshops on reducing food waste were conducted, along with a semester-long course for a diverse range of design students focussing on designing innovative solutions to food waste on campus.

In response to this industry-supported design program, the authors developed a model for a Transdisciplinary Living Lab (TDLL). The TDLL sought collaboration with industry, government and university operational staff, and also provided an opportunity for students to engage with the Sustainable Development Goals (SDGs) and the closely related concept of planetary boundaries while fulfilling their course requirements. The decision to incorporate the SDGs and the concept of planetary boundaries into the TDLL model was made to encourage students to critically reflect on the impact of their design solutions on global systems, in this case—food waste management systems. In addition, the TDLL helped to meet the two universities' commitments to the SDGs outlined above.

When Western Sydney University became a signatory of the UN's Sustainable Development Goals (SDGs), a number one priority was to make this commitment visible via sustainability focused campus Living Labs. Western Sydney University has a long history of experimental initiatives that have taken advantage of Western Sydney University's large, peri-urban campus to showcase best practice environmental management in an educational setting, including the Hawkesbury Water Recy-

[5] http://www.un.org/sustainabledevelopment/sustainable-consumption-production/ (accessed 28/08/2017).

cling Scheme, Western Sydney University Farm and the historically significant River Farm, championed by the University's Office of Sustainability. This history provides an ideal context for TDLL initiatives to build on, particularly across the University's multiple urban campuses. It also offers a unique setting for cross-institutional collaboration. For example in 2010–11 the Design and Agriculture faculties collaborated on the project 'Transitioning to Sustainable Sanitation Futures' (Mitchell et al. 2012), which had a proto-TDLL format involving academics, industry and students from a range of disciplines in a journey of complex and collaborative problem solving (Lopes et al. 2012).

2 Translating Commitment to the SDGs into Practice: The Transdisciplinary Living Lab

In defining the TDLL, we must first define transdisciplinarity. The term 'transdisciplinarity' (TD) has no single unified meaning (Jahn et al. 2012), it can, as Pohl (2011, p. 98) suggests, be perceived as a '*structured plurality of definitions*'. Reiterating this idea, Ison (2017) observes that different histories have given rise to different understandings of TD. Riedy (2017) defines transdisciplinary research as a '*bundle of interwoven social practices that takes different forms in different local and historical contexts*'. While there is no single definition, there are overarching characteristics of TD research and practice (Jahn 2012). Wickson et al. (2006) identify three primary characteristics of transdisciplinary research, that is (1) it is problem focused, (2) it has an evolving methodology and (3) it is highly collaborative and participatory in nature.

Mobjork (2010) observes there are close similarities between transdisciplinarity and sustainable development research. They are both multi-faceted and problem focused, interested in action, deploy participatory approaches, and aim to address values and normative judgments in the name of the common good (Klein 2017). Jahn et al. (2012, p. 9) goes further, noting that TD is also 'interventionist' in the way that it frames, structures, and organizes the societal discourse about the problem being addressed.

While *observation* may provide a way of examining 'what is', research taking an *interventionist approach* goes further to ask 'what could be' (Brown 2010). In the context of the TDLL, the question is what could a sustainable food (waste) system look like in the future, and how might this be achieved? In developing educational programs a key distinction between observation and intervention is how the researcher/student reflexively understands their position in the field of research, representing a shift from 'observer' of social reality to agent of change (Fam et al. 2015).

In developing the TDLL model, the authors took the view that for a student/researcher to develop a rich enough understanding of the problem being investigated to ultimately find a point of intervention, they needed to work from inside the system. Utilising the campus as a living laboratory provided the context for students to engage with the food waste system daily and to further investigate both the visible and commonly invisible components of the system i.e. technologies, actors (cleaners, facilities personnel) and practices.

Experiential, problem-focused learning, which is deeply rooted in local context, has been theorised and practiced since the turn of the century (Dewey 1938). However the specific concept of the "Living Lab" is more recent. The Living Lab concept, which first appeared in academic literature in the 1990s, is often credited to William Mitchell, a professor at Massachusetts Institute of Technology (Dutilleul et al. 2010, p. 63). Mitchell identified that contemporary information technology provided an opportunity for monitoring human interaction with innovations outside of the typical laboratory environment. His approach towards researching these innovations shifted from "in vitro to in vivo settings" (Dutilleul et al. 2010, p. 63). This initial model of the Living Lab was described as providing a space where designers and researchers could observe users and test models through hypotheses. This concept later evolved into utilising campus space specifically as a location for these innovation models to be tested.

Dutilleul et al. (2010, p. 64) propose five distinct meanings to the term "Living Labs":

(1) "In vivo monitoring of a 'living' social setting."
(2) An "innovation system" composed of multi-disciplinary networks working in collaboration to solve a research problem.
(3) An approach in which users are engaged within a product development process.
(4) A term used to describe the organisations which facilitate and maintain a collaborative research network.
(5) A descriptor for the European movement which emerged in the mid-2000s as a co-ordinated and common innovation system between European research networks.

Of these meanings, "Living Labs" is now commonly understood to be a fusion of the first three: a collaborative test of an innovative approach to a problem occurring in a "living" social environment where end-users are involved (Daniel 2017, p. 2). This fusion of the concepts is often still separated in the literature around Living Labs. Curtis (2015, p. 4), for example, proposes that a split in the literature occurs around the Living Lab as a "physical space where subjects are embedded into real-life situations, examined and included in the co-creation of knowledge"; or, the Living Lab as an "organisational arrangement involving multiple stakeholders that carry out testing, research or knowledge-creation." In order for the Living Lab process to be best understood, it is vital to consider these elements as an integrated and cohesive whole (Daniel 2017, p. 2).

The Living Lab concept is increasingly being used to explore the multi-dimensional and dynamic (or 'wicked') nature of sustainability-related problems in a university setting, as a university community is inclined to nurture innovation. The socially and geographically bounded context can help to rein in complexity (or at the least, render it observable). This also ushers in a new approach to learning, where students can "discover[…], examine and fail" in a "safe environment" and that the exchange of knowledge supported by Living Labs taps into the underutilised "brain power" of the entire university, including its stakeholders (Graczyk 2015, p. 32). The university has the potential therefore, to act as a local focus point for broader global concerns such as is represented by the SDGs. We can see a strong relationship between the sustainability-focused Living Lab and Jahn et al.'s (2012) characterisation of transdisciplinarity. Problems are discovered rather than solved, which makes the Living Lab an ideal context for transdisciplinary learning and normalizes education for sustainable development.

The relationship between 'transdisciplinarity' and living laboratories is not new. For example, Scholz and Marks (2001, pp. 251–52) have advocated for 'transdisciplinary laboratories' where scientists and practitioners work together for mutual benefit over periods of time. The novel approach taken by the authors is in implementing 'transdisciplinary living laboratories' as an educational platform and site for mutual learning of university operational staff and students. The expanding location of transdisciplinary research has the potential to '*heighten awareness of the public space, and amplify the concepts of deliberative democracy and socially robust knowledge*' (Klein 2017, p. 12).

3 Operationalizing the Transdisciplinary Living Lab Model (TDLL)

The TDLL was designed and delivered to students in three distinct and iterative stages (see Fig. 1.) which included:

(1) ***Entering the living lab***: introducing collaborative teamwork processes, expectations of joint problem formulation and critical reflection on students' impact on the food waste system
(2) ***Transdisciplinary learning***: introduction to the concept of co-producing and integrating knowledge in collaboration with transdisciplinary partners and actors in the system and research as a process of system intervention
(3) ***Global context***: introducing the SDGs and planetary boundaries as guiding frameworks to develop, refine and justify final designs, articulating global impact of local practice and defining the implementation and assessment of societal and scientific outcomes of the final design solutions.

Our approach in the TDLL was to integrate critical TD skills including collaboration, communication and knowledge integration (Fam 2017) with design specific competencies to generate a system-sensitive design curriculum. The TDLL not only required students to develop design interventions/improvements to complex challenges (such as food waste) but also consider the broader impact of their designs in regard to the SDGs and planetary boundaries. The TDLL model was developed and iterated as a third-year design studio (2016, 2017) closely involving students, industry, government, facilities management experts and design and sustainability

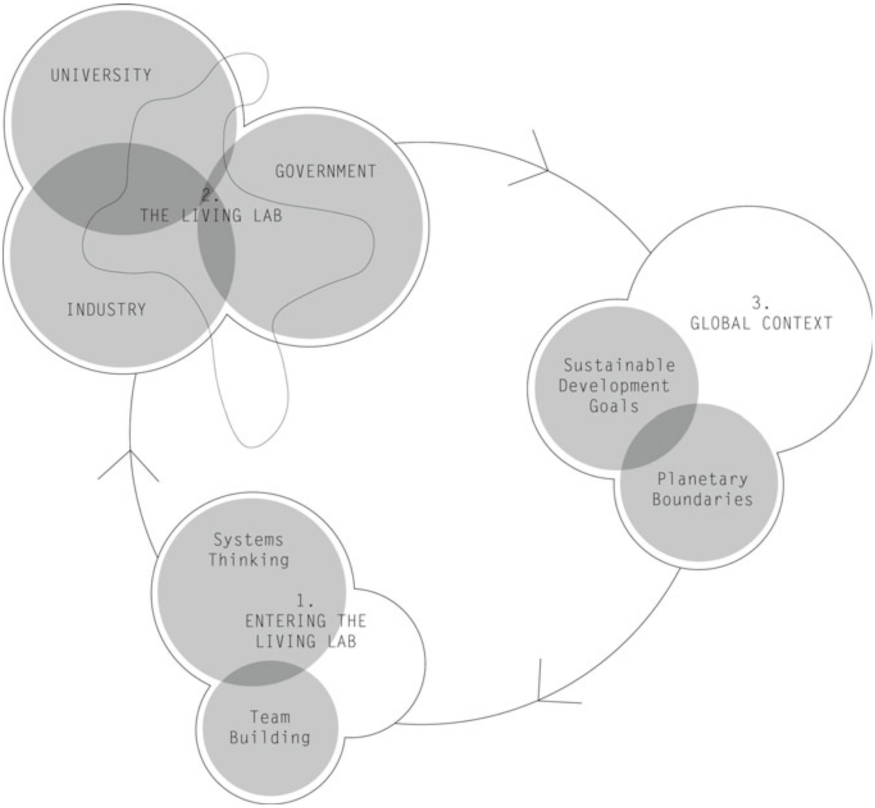

Fig. 1 Overview of key stages of skills development in the transdisciplinary living lab model (Adapted from Hummels 2011)

academics who collaboratively worked toward more effectively managing food waste on-campus, with the long-term goal of processing 100% of the food waste for productive reuse within the Sydney precinct. With feedback from, and interaction with, expert stakeholders, design students worked in teams of 4–6 members to jointly develop briefs and design interventions.

The practice-based nature of the TDLL was supported by the NSW Environmental Protection Agency which was involved in not only funding the installation, research and evaluation of the viability of a food waste management technology on-campus, but also participated as expert panel members.

As a publically accessible output, the TDLL adopted a continuous online class blog (See: https://wealthfromwaste.wordpress.com) and Instagram feed (See: https://www.instagram.com/wealthfromwaste/), where students and educators share research, ideas, reflections and feedback on designs in a dynamic open forum. The blog created an archive of on-going learning with consecutive cohorts of students, challenging the idea that a problem, such as food waste management, can be solved within a set period of time. The TDLL proposes that sustainability-oriented challenges are an on-going process of learning and adaptation, rather than an end goal. In addition, the TDLL blog encouraged students to build on previous iterations and learning of the project, rather than 'reinventing the wheel' each time the subject is offered.

3.1 PHASE 1 Entering the Living Lab: Scale Matters

The initial phase and entrance into the TDLL had two goals. Firstly, to encourage students to articulate a form of teamwork and collaborative research that was appropriate for team members and in the process, identify individual strengths, weaknesses and potential contributions each participant might make to the project. This required students to reflect on and document how they planned to collaborate across design disciplines and as a group, and how they would approach decision-making and collaborative research. This process was formalised in an agreed upon document which clearly defines how team members will work together, overcome inherent challenges and jointly formulate problems and potential solutions.

The second goal of this phase was to encourage students to identify their own individual contribution to food waste on a daily basis, both on-campus and within their own homes. In the process, they further developed design skills such as critical self-reflection, systems diagramming/thinking, self-auditing and environmental auditing. Students conducted self-audits of all the organic waste streams they produced within a 24-h period and reflected on embedded habits, values and beliefs in managing waste streams more broadly. While auditing is a practice conventionally associated with accounting, it was adopted as a way for students to document and categorise their waste as individual components inseparable from broader food waste systems. This facilitated students to identify and position themselves as complicit actors, as well as agents of change, in the food waste system. Design skills were used in the self-auditing process with mapping, photographing, documenting, quantitative calculations and journaling of food waste produced. This sensitised students to the theme of the studio and primed them to identify food waste on campus as part of a broader urban food system ecology within which they are intimately involved and implicated. From a transdisciplinary perspective of skills development, self-auditing exercises prime students to question what 'valid data' are, and whose perspective should be valued. Focusing on these skills helped students to recognise that 'digging where you stand' is a good way to start being an active political agent when dealing with complex sustainability problems (Fry 2009, p. 224).

Beginning the TDLL at the microscale where individual practices associated with food waste production are revealed, encourages students to realise that scale matters and that local dynamics and cultural practices are crucial to investigate when aiming to intervene in a system. The first step in comprehending the enormity of the food waste challenge and its environmental, social and economic impact is to reflect on one's own contribution to the problem under investigation. The weekly audits

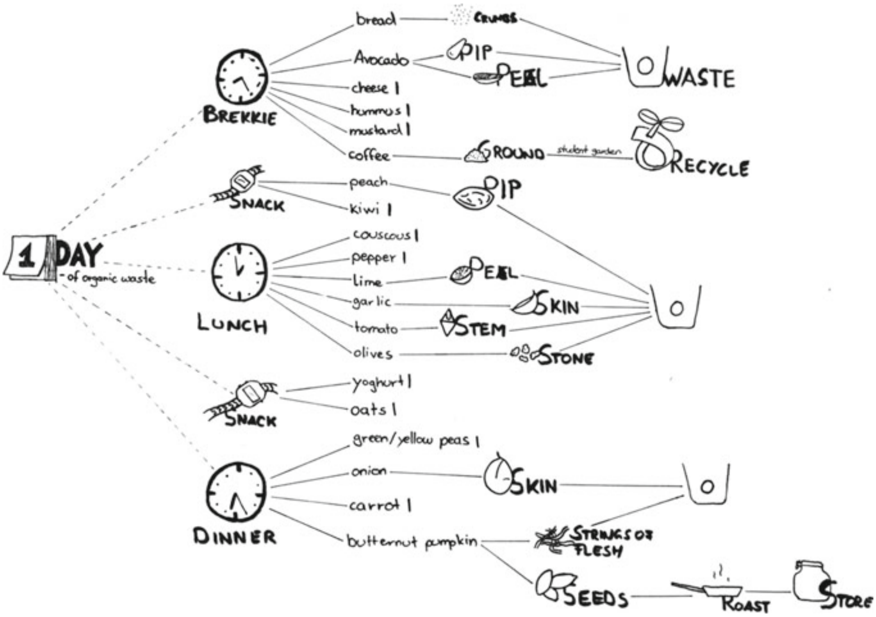

Fig. 2 24-hour self-auditing exercise—student work

provided the first step in comprehending the mutli-scalar challenge (See below for examples of food waste audits) (Fig. 2).

The first phase of the TDLL model frames the microscale as critical for understanding how they might intervene in a system of food waste management by exposing students to their own cultural and everyday practices, inconspicuous habits of consumption and waste production rates. The following stages build on the microscale and introduce students to multi-scalar influences on food waste management i.e. university, local city, state-wide and regional influences. Relationships between macro and microscales, and the interactions between macro-structure and micro-agency affect the way waste is managed. Improving the understanding of linkages between microscale and macroscale phenomena and impacts is an intellectual challenge for students to grasp and was introduced in the following stages by incorporating reflection on SDG 12 and planetary boundaries as a guide for final design solutions.

3.2 PHASE 2 Transdisciplinary Learning: Multi Scalar Perspectives

Once students had entered the TDLL, reflected on their own role in the food waste system and learned to negotiate team dynamics, the second phase was spent gaining insight into the food waste system from multiple disciplinary and lay perspectives.

This was achieved through collaborative expert panels, Q&A sessions and evaluation of student progress by project partners and industry and government experts. Importantly, the end-user perspective of the system was sought, with students invited to produce primary research data to support and justify their final design interventions. Students drew from a range of system thinking tools and methods including stakeholder mapping, 'rich pictures', and causal loop diagramming to facilitate teams to initially identify their own knowledge of the system, interactive components and critical actors in the system. Primary research methods included interviews, surveys, shadowing cleaners to identify everyday cleaning practices and participatory observation.

Taking the position that a variety of different perspectives on the issue of food waste management on-campus provided a richer problem context, the authors engaged an expert panel to work with students over the duration of the TDLL. This was achieved in a number of ways, most successfully through a half-day presentation and Q&A where representatives from local council, the NSW EPA, technology developers and UTS facilities management staff provided their own perspectives on the issue of food waste as well as identification of where innovation is currently occurring and is expected in the near future. Student engagement with expert stakeholders in the system provided not only multiple perspectives, but also insight into contested viewpoints, values, approaches and personal and organisational commitments to creating change while allowing students the opportunity to further develop skills in critical listening, thinking and reflection.

The second phase encouraged students to view waste from a 'multiscalar' perspective, as a result of a complex global, national, local, and individual set of processes and practices. It also examined the often hidden dynamics involved in creating the conditions for the regulation and management of waste.

3.3 PHASE 3 Global Context, Local Practices

Phase 3 of the process required students to justify their final designs in relation to the methodological approach, knowledge gained throughout the process (including the global context) and TD skills developed i.e. collaboration, communication (in its multiple forms) and attempted integration of knowledge through a collaboratively developed design solution.

In this phase of the TDLL in 2017, students were introduced to the broader global context, including the concepts of the SDGs and the planetary boundaries, e.g. the idea that there is a need for humanity to function within the boundaries of a safe operating space (Rockström et al. 2009). This introduction had two aims. Firstly, to broaden the perspective of the problem of food waste beyond the campus to city, state, national and global scales, making the boundaries of the Living Lab porous. Secondly, to support students to leave the lab with insight into the interdependences and impacts associated with system design. Students were therefore invited to reflect on their own design interventions to improve the food waste management system and how their designs took into consideration the broader global context of planetary boundaries and SDGs.

Engaging with the SDGs and Planetary Boundaries in 'Three Acts'

The engagement of student/researchers with the broader global context was delivered in three Acts.

Act 1 explored how the earth systems which support the emergent property of 'life' (Capra 1996) are severely disrupted. Included in the discussion were the concepts of The Anthropocene (Lewis and Malsin 2015); The Great Acceleration (Steffen et al. 2015); The Tipping Points (Rockstrom et al. 2016); and The Planetary Boundaries (Rockstrom 2009). As much as possible, the explanation of these concepts included a specific grounding within the concept of food waste. For example, in discussion of the Great Acceleration, the social and environmental trends relating to food production and waste were identified. The Anthropocene identifies significant changes caused by human activity in the atmosphere, ocean, land and life, including changes in the Nitrogen cycle. Through use of a mind-map, the specific linkages between changes in the Nitrogen cycle, and food production/waste were explored. After introducing and offering examples of the nine planetary boundaries, the student/researchers were then tasked with making the connection between dealing with food waste and potential impacts on the planetary boundaries. After the activity, student/researchers were asked to reflect on:

- To what degree does the food system interact with the planetary boundaries, and why?
- Why is dealing with food waste important from a planetary perspective?
- How was that exercise helpful (or not) for you as a designer?
- What are the different levels at which designers can engage with the planetary boundaries?

These reflections highlighted the challenges of engaging design students in what can be difficult and complex scientific concepts. Future iterations would allow more time to do this activity.

Act 2 focused on understanding the concept of '*systemic intervention*'. As mentioned above, the purpose of this exercise was to demonstrate that there are many interwoven causes and effects of food waste within campus, and that designing an intervention is most effective when the system has been mapped and observed. To begin mapping the system, students undertook a root cause analysis for the question: What is driving food waste at UTS? In this analysis, mind maps were created by asking "why" for all of the different answers to this question, five times. The students were then invited to add these insights to causal loop diagrams they had created earlier in the semester on the food waste system on campus (e.g. systems thinking was interwoven through the whole semester).

Students were introduced to Donella's Meadows notion of leverage points for change in a system (1999; Abson et al. 2017). We discussed example levers of change for each of the high-level system characteristics (e.g. parameters, feedbacks, design, intent). For example, we discussed how 'the price of food' is a parameter, and how this lever for change can influence the food waste system, whereas on the other end of the spectrum, we discussed several food waste paradigms, i.e. There is an 'away' to throw food waste to, and what different scale of impact would be by addressing paradigms governing the systems verses parameters within the system.

Based on the global context of **Act 1** and the notions of designing systemic change in **Act 2**, the Act 3 focused on designing '*glocal*' *interventions* (globally aware, yet locally relevant). The context for **Act 3** included the introduction of the Earth Charter and the Donut Model (a safe *and just* operating space) (Raworth 2017), and the introduction of the SDGs. Here the history of the development of the SDGs, the purpose, and the adoption by Australia and the universities involved were discussed. The SDGs were temporally contextualized by introducing the notion of The World in 2050,[6] which sets the SDGs as the goal for 2030 and the planetary boundaries as the goal for 2050. Student/researchers then actively explored the SDGs, the concept of food waste and their designs. Specifically, in order to improve the impact, and explain the benefits of their designs they investigated and mapped out the relationships between the goals, targets and food waste streams. This included reflection on the following questions:

- How does addressing food waste help achieve the SDGs?
- Which **goals** and **targets** are **primary** (strongly linked) and **secondary** (less strongly linked) to addressing food waste?
- Which **indicators** are relevant to food waste management, and to what degree could the impact of your proposed design be monitored by these indicators?
- How are these inter-related?

As a final task, students were invited to develop a broader perspective on their learning through a reflection process in which they translated their TDLL experience into a prospective job application on the class blog, highlighting the skills developed and experience gained during the TDLL. This became an opportunity for the authors to evaluate not only how students had incorporated a 'global perspective' on the potential impact of their final design solutions on the planet, but also what—from their own admission—had been the greatest learning experience and the most valuable skills developed.

One student commented: *One of the most influential moments I've experienced was to [learn]… about the Sustainable Development Goals (SDG). I personally think that design has a power to change one's mind, therefore, I needed to understand how habitual changes regarding food waste…disposal in general impacts us as a nation. In total SDG focused on 17 goals to achieve in the next 15 years, which opened my eyes to the possibility of design solutions in which I would love to contribute.*

[6]https://rethink.earth/the-roads-to-2050/.

4 Conclusion

The conventional domain for many universities to address sustainability lies within schools of the environment, focusing primarily on resource management (Hoffaman et al. 2017). In contrast, Living Labs allow for the development of different models for sustainability education that operate within and across university faculties (and inter-university collaboration). The challenge of introducing and standardising collaborative research across disciplinary faculties in degree programs (Fam et al. 2018) attests to the need to consider and nurture multiple models of inter- and transdisciplinary education, of which a TDLL is one.

In the higher education context, on-campus Living Labs are one way to create an environment that supports TD research. Living Labs bring members of the public, business, government and researchers together to co-create services, systems, technologies and societal solutions. Linking curriculum, operations and research, Living Labs offer holistic and systemic ways to support the university, and its researchers, students and graduates to practically meet the SDGs (Reynolds et al. 2018). Utilizing campus infrastructure as a living environment for applied, collaborative learning not only advances sustainability on campus but prepares students to be active, engaged citizens, and to continue this work beyond their life at university.

On a final note, as educators, the authors believe that '…*a fundamental change is needed in the way we think about education's role in global development because it has a catalytic impact on the well-being of individuals and the planet'* (*Irina Bokova, Director General of UNESCO,* UNESCO 2017). This chapter has aimed therefore to share our experience of designing and delivering context-dependent, collaborative learning experiences that incorporate the SDGs and planetary boundaries not only as a concept for reflection by students but as a guiding frame for designing a more sustainable world.

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Sustainability in Higher Education: Beyond the Green Mirror

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Abstract With living labs and co-production increasingly playing a vital role in universities, the University of Bristol is taking significant and drastic steps in incorporating both of these themes into its strategic planning. This paper discusses how the Bristol Futures integrated approach, and specifically its Sustainable Futures pathway, are taking sustainability beyond its obvious and most frequently used links to connect it to subjects like homelessness and resilient cities, personal happiness and wellbeing and a sense of purpose in life. The aim of this approach is to provide a framework through which the learners can engage with other roles and disciplines, while using sustainability as a lens to achieve this. The living lab model provides us with the tools and approaches needed in order to use a new online Sustainable

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Futures course, designed by a University of Bristol team as a platform where learners from across the world can interact. The focal point of Bristol Futures is a dual approach—that learning, and change come from the dual approaches of theoretical understanding and practical experience. Using sustainability as a lens and the Sustainable Development Goals as a framework, students explore local and global challenges through a series of interdisciplinary case studies (Wood 2004) and reflect on how they would best be positioned to address those challenges (Martin and Jucker 2005). It then harnesses the University of Bristol's international award-winning reputation and the Bristol Students' Union *Learn Act Engage Create* approach to give students engaged learning opportunities to turn theoretical study of sustainability into practical action in communities. Bristol Futures provides students with a unique combination of skills that will enable them to become agents of change on a local and global level, using online courses, face-to-face study and engaged learning to ensure they take sustainability outside the lecture rooms and turn it from theory, to practice and a way of life.

Keywords Higher education · Sustainability · Education for sustainable development · University of Bristol

1 Introduction

ESD has real impact and meaning globally, as evidenced through the outputs of decades of efforts championed, amongst others, by UNESCO. This includes tackling issues of climate change and cultural diversity, advising policy makings, empowering learners and leading change through education, discussion and international initiatives (UNESCO 2014). One of the major culminations of these efforts is the Global Action Programme (GAP) on Education for Sustainable Development (UNESCO 2015). Other initiatives include the Sustainable Development Goals Accord (SDG Accord) that draws together the University and College sector's collective response to the SDGs (launched in September 2017, see http://www.sdgaccord.org/).

The University of Bristol is a GAP and SDG Accord partner institution. In response to these initiatives, it has developed *Bristol Futures*, a creative and integrated approach to curriculum development which aims to develop student skills and values in *sustainable futures*, *global citizenship* and *innovation & enterprise*. The Sustainable Futures pathway takes sustainability beyond its obvious and most frequently used links, to connect sustainable development to subjects like homelessness and resilient cities, personal happiness and wellbeing and a sense of purpose in life (Sterling 2003; Sterling 2010; Sterling 2011). This paper will give a brief history of Education for Sustainable Development work at University of Bristol. We will introduce the new Bristol Futures initiative and we will discuss the Sustainable Future online course and the opportunities and challenges it has presented in developing students with the skills and values needed to tackle local and global challenges.

2 Sustainability at Bristol

Much like the City of Bristol, the University of Bristol has a long history of sustainability action, winning numerous awards for its work. Sustainability remains one of the central strands shaping the University's vision of the future. The University has been working to create a culture of sustainability for many years, pioneered by the work of Professor of Sustainability and Law, Chris Willmore, and Martin Wiles, Head of Sustainability (Walsh, in review). From 2011, University of Bristol joined the HEA Green Academy initiative and a newly formed ESD team developed a five-ring model, "to map and assess progress for sustainability in four key areas: estates, the informal curriculum, research and the formal curriculum, which are encompassed by community" (Tierney et al. 2015, p. 509), to demonstrate that we need to not only focus on changes in the formal curriculum to include economic, environmental and social sustainability, we need to reinforce what students are learning outside of the classroom through the subliminal curriculum and their extra-curricular activities.

The ESD team developed several projects to support academics and students to embed sustainability in their curriculum. They developed a curriculum mapping project which helped to understand the changing nature of the formal curriculum, they conducted regular reviews of the ESD content within all our units and programmes (Tierney et al. 2015). This helped shape engagement with academic schools. The team provided a wide range of online resources, tailored for each school, as well as delivering training sessions to staff and students as part of the CREATE scheme, the University's continuing professional development scheme for academics. Another key method for embedding ESD within the curriculum is through the Green Apple Scheme, a funding mechanism that supports academics who wish to develop new teaching and learning practices. Through this scheme, teaching staff receive support to develop projects that embed ESD principles within their discipline, and students can contribute ideas and suggestions to help shape the future of their courses.

In 2013, the University of Bristol Students' Union (Bristol SU) received £175,000 of the NUS' Students' Green Fund to develop Get Green—a two-year project which aimed to create a transformational change in student attitudes and behaviours towards sustainability and sustainable development. Bristol SU aimed to build on the work of the University of Bristol ESD team to facilitate students to develop the skills and values to create positive sustainable change, leading to a cultural change towards sustainability (Walsh 2015). To deliver on an extensive range of targets the Get Green team developed a four-step approach—Learn Act Engage Create—to engage students in economic, social and environmental sustainability. The approach was underpinned by active learning theory and maximised peer-to-peer engagement. The four-step approach involved students engaging with ESD through their formal curriculum and then building on their experiences by participating in, and leading, projects and campaigns outside of their course (Walsh 2015; Walsh, in review).

3 The City of Bristol

Bristol has a strong tradition of activism, with citizens who are engaged, expressive and ever-ready to get involved, and the city of Bristol has many firsts. The City has a history as a hub for sustainability activism. Windmill Hill City Farm was the first city farm to be created outside of London in 1976, it's a place where residents can learn about nature and sustainable food practices (Brownlee 2013). The Bristol Green Capital Partnership is a unique collection of over 800 organisations in the City who share a vision for a sustainable Bristol, they connect and collaborate on events and campaigns around energy, waste, food, air quality and nature (http://bristolgreencapital.org/). In 2015, Bristol was the first UK city to be named European Green Capital. This award celebrates and promotes innovative responses to urban environmental challenges. Bristol impressed with its commitment to clean transport and energy, and its role as a low-carbon hub of industry. The city influenced international policy at the UN climate change summit in Paris in 2015, sharing best practice and presenting ambitious sustainable action. Bristol was the UK's first cycling city, birthplace of the National Cycle Network and home to Sustrans, the UK's sustainable transport charity. One major achievement of Bristol students through European Green Capital activity was the contribution of over 100,000 h of students volunteering for sustainability-related projects in one year (Clayton et al. 2016).

4 Living Labs

In the Joint Program Initiative (JPI) Urban Europe Strategic Research and innovation agenda an urban, a living lab is defined as: "A forum for innovation, applied to the development of new products, systems, services, and processes in an urban area; employing working methods to integrate people into the entire development process as users and co-creators to explore, examine, experiment, test and evaluate new ideas, scenarios, processes, systems, concepts and creative solutions in complex and everyday contexts" (JPI Urban Europe 2013). Additionally, and as is discussed in Ariane König's and James Evans' book on "Experimenting for sustainable development? Living laboratories, social learning and the role of the university", living labs can provide a space where multiple stakeholders can address local and/or global challenges and generate knowledge that is applicable to real-world situations (Konig and Evans 2013). Apart from what happens within the living lab itself, it is crucial to have a good interaction between the lab, and what is defined as 'a real-world situation' to achieve long term impact within and outside of the lab. Much like we need collaboration between disciplines, there is also an equal need for collaboration and co-production of knowledge and initiatives across sectors to address the societal challenges we are facing globally and locally. The City and the University of Bristol interact dynamically, and are in a way, very similar systems that interact and overlap with each other both spatially and temporally (Bourn 2009). That interaction can and should play an integral part of how we understand sustainability and how we can mould the future of the university, the city, the students and residents. The Bristol Futures initiative introduces local challenges in the University of Bristol's curriculum, by showcasing what the residents of the City of Bristol are doing to address these challenges. We give students an insight into how the 'City' views sustainability and what it means for wider community. The students can find similarities between those initiatives and their own interests and identify where they can join efforts with other teams and increase impact. They can also identify new challenges or ways to engage, interact in a way that helps the community, and this is fertile ground for new, innovative thinking, and genuine bottom-up solutions to the problems faced by the city and the university. Using the living lab approach, untapped human resources concentrated by the University can be fed back into the community, producing a fertile, iterative way to exchange knowledge, expertise and life experiences. By presenting this vibrant community to our students and learners, we create strong links between the 'student-resident' and 'the University-the City' that transcend those identities and form a new identity, that of the 'engaged citizen'.

5 Bristol Futures

Bristol Futures is one of the University of Bristol's strategic projects that seeks to equip all students with the skills to be informed citizens in our changing world and will be completed in three phases (University of Bristol 2016). The core of Bristol Futures is formed by three 'pathways', defined as:

1. *Sustainable Futures (SF)*—equipping students to engage with the challenges of globally improving the quality of life for humanity while sustaining the natural environment and finding ways of living with the environmental change that we cause.
2. *Global Citizenship (GC)*—fostering the critical self-reflection and understanding students' need to negotiate the challenges of energy and resource management and food security, tackle international insecurity and engage with culture and heritage in an increasingly globalised world.
3. *Innovation and Enterprise* (IaE)—enabling students to act on their ideas, use their initiative, and shape change in diverse sectors.

A progressive initiative that challenges traditional forms of pedagogy by combining innovative teaching and learning strategies. Throughout its growth, Bristol Futures has always tried to be first and foremost inclusive of all students, by providing online courses open to everyone and both postgraduate and undergraduate students will see the three themes reflected in their core curricula. At its heart, it aims to reach all students, not just the most engaged, and create opportunities that will build inspiring as well as inspired graduates. Additionally, it is fully co-designed. The Bristol Futures Student Advisory Group consists of almost 100 students from across the University. It has advised the project board on curriculum, branding, the personal development planner and the online element of Bristol Futures. The group is a diverse community of students who are passionate about education and unafraid to voice their opinion on the various areas of Bristol Futures they have co-designed. Other areas of the project invite students' participation through regular workshops, in addition to the core advisory group. This aspect of co-creation has been a unique element, that makes this initiative very different from similar initiatives in other universities.

6 The Sustainable Futures Online Open Course

A study by MIT shows that online courses can teach at least as effectively as traditional classroom courses, additionally, they found that this is true regardless of how much preparation and knowledge students start out with (http://hdl.handle.net/1721.1/90300). Evidence shows that the students of the University of Bristol are engaged. A recent University of Bristol Students' Union (Bristol SU) survey in 2017 of c. 1000 students showed that 17% of students volunteer on Bristol SU projects and 33% volunteered outside of the University on community-led social or environmental justice projects (unpublished internal data provided by Students Union, 2017). This section will focus on the Sustainable Futures online open course (one of three themed courses offered by the University of Bristol from 2018). The course runs over four weeks, with three hours of interactive and self-directed content per week. This course introduces learners to sets of challenges where several sustainable development goals are grouped. The learner can then fully understand and experience the purpose of sustainable development, and how the sustainable development goals can contribute towards the improvement of the quality of life of humanity, while preserving and improving the earth itself. The learner is not expected to have a previous comprehensive understanding of such challenges and the different approaches to engage with them. They are given the chance to explore several case studies of individuals and organisations which have engaged with some of these challenges. The course was designed by an interdisciplinary team at the University of Bristol: Chris Preist, Professor of Sustainability and Computer Systems; Eleni Michalopoulou, a PhD Student in Atmospheric Chemistry; Dr Aisling Tierney, ESD research associate and archaeologist; and Hannah O'Brien, online and blended learning designer. The diversity of the team's expertise ensured a balanced design that speaks to learners from different subject backgrounds. Case studies formed the core of on which text the learning design framework on which text-based and interactive elements were developed upon.

As discussed above, for the living lab approach to have a long term, and applicable—in a 'real world situation'- impact, the stakeholders need to understand each other's context to work together and promote knowledge and research and offer solutions. Co-creation and co-production were both key ethical and design principles. As such, the design team invited the participation and contribution from beyond academia. The results of this approach achieve the following ambitions:

(a) The learner interacts with more ideas than those found in a typical academic environment.
(b) The student (and learner) is given the opportunity to explore what sustainability looks like for the City of Bristol as well as the University of Bristol and through this they can:

    (1) Identify similar challenges that the two stakeholders are facing.
    (2) Identify similar bottom-up initiatives that were developed by the two stakeholders independently.
    (3) Examine similar challenges at different scales.
    (4) Learn about the interaction of the university and the city through policy making, bottom-up initiatives.
    (5) Explore different roles that people can adopt when striving to address a challenge.

(c) The student is exposed to the theory behind holistic sustainability in an interactive way through the four weeks of the course and through the discussion that will take place in the course.
(d) Through the above, develop and adopt the identity of the engaged citizen.

Learners are given information on how to join local initiatives, ways to contribute and interact as well as spaces and events where they can engage with others. Additionally, and in order to give the student and the learner a sense of the bigger picture, there are also challenges not strictly local to Bristol. This showcases the scale of modern challenges and the need for collective action beyond the University, and the City. By engaging with these case studies, as well as the rest of the course, learners engage with how knowledge of sustainable development has been applied in different situations, the nature of the challenge, the approaches used to tackle it, and how the different roles involved interact with each other. We also present them with more personal reflections from the people involved: what motivates them, what difficulties they have faced personally and what helps them through these difficulties. The case studies are compiled by stories from people who are promoting positive mental health and happy communities to tackling local homelessness and working with large corporations to reduce microplastics, and in doing so, hopefully, inspire the learner to learn more or even become involved themselves. Instead of presenting our students with a list of Sustainable Development Goals, we decided to use sustainability and therefore, the sustainable development goals themselves, as a lens through which the student is given the opportunity to closely examine small and large-scale challenges. Starting from mental health and then moving on to Bristol specific and global specific challenges, we take the student through a journey of personal, local and global sustainability. By focusing more on self-reflection, we give the student time to explore different roles through which they can address modern day challenges. This course is for anyone interested in living in a way which makes a difference in the world, in ways both small and large. It gives the learner the chance to reflect on what they do in their life already, as well as how they could make changes for the future. During this course the learners have the opportunity to reflect on what makes a ‘happy’ and 'satisfying' life, in general and for them personally, to understand the different ways people find a sense of purpose and fulfilment in their life and activities, exploring what gives them such a sense of purpose in this way, to understand how one rarely 'make a difference' in the world on their own. Also, they are shown how change happens through several actors playing different roles and working together to reach a shared goal as well as the timescales of that change. They can then reflect on which types of roles appeal to them personally (both in terms of skills exercised and what they enjoy) and consider how they interact with others' roles. Finally, they are shown some of the challenges that they may face when attempting to 'make a difference' in the world: ranging from the personal to the global.

7 Conclusion

At the University of Bristol, sustainability is now a central pillar of all educational efforts through the theme of Sustainable Futures. This theme permeates the taught curriculum and optional voluntary opportunities alike so that all students can engage meaningfully with sustainability. Students have also been an integral part of the development of this position so that Sustainable Futures responds to students' interests and priorities. The goal of inclusivity and co-production also extends to our local and international communities. This is most visible in the design of the online Sustainable Futures course that features case studies and contributions from a broad spectrum of stakeholders. Institutionally, the University has embraced a broad meaning for sustainability, not just in theory but in its practice of what it considers to constitute "sustainability". The case studies that form the core of the online course include topics such as food poverty, microplastics, eco-tourism, climate change, and homelessness. In our degree programmes, reviews of the curriculum use UNESCO's definition of ESD (political, environmental, economic, social and cultural sustainable development) (Tierney et al. 2015). Both our research and teaching approaches are increasingly engaging with the SDGs. The online course presents Sustainable Futures as a means to share the Bristol approach globally, to create a digital "living lab" that connects global learners and local communities. Here, it takes forward the concepts of *Learn Act Engage Create* and the wider Bristol ethos of putting theory into practice. The focus on skills and self-reflection circumvents a didactic approach to learning towards a meaning-driven context-based reflexivity. The online course also presents Bristol's concern with catering for its own students and communities, and the institutional ethical imperative to be an instrument for positive change in the world.

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The EDINSOST Project: Implementing the Sustainable Development Goals at University Level

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Abstract This article presents a review of the generic competencies in sustainability in Higher Education (HE). It provides a compilation of these sustainability competencies as an instrument to facilitate their assessment in university studies. Within the framework of the European Higher Education Area (EHEA), the Bologna process proposed working by competencies. It will not be an easy task to implement these competencies, together with the global challenges of the Sustainable Development Goals (SDGs), at university level. Higher education institutions (HEIs) have a key role to play in the implementation of the 2030 Agenda for Sustainable development adopted at the United Nations, and developing sustainability competencies is a way to promote it. This paper presents the first result of the EDINSOST project: a competency map on sustainability. The map has been developed within the EDINSOST project, whose objective is to train graduates capable of resolving the challenges facing our society by integrating training in sustainability competencies into the Spanish University System (SUS). At eight Spanish universities, this map has been successfully adapted to several undergraduate degrees in education (Primary Education, Pre-School Education, Pedagogy and Social Education) and a master degree programme in Environmental Education.

Keywords Competency map on sustainability · Education for sustainable development · Sustainable development goals · Higher education · Sustainability training

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1 Introduction

This paper reviews the generic competencies in sustainability in HE and provides a compilation of these competencies in sustainability as a resource to facilitate their assessment in different education degree programmes. This important task of assessing generic competencies in sustainability is not easy since two new paradigms for teachers converge: first, the adaptation of the new educational model of assessing competencies and, second, the development of sustainability awareness leading to a better world for new generations.

The framework of the EHEA defines and evaluates all kinds of educational qualifications and establishes what skills students must achieve (EHEA 2009). The Bologna process in Europe and the Decade of Education for Sustainable Development 2005–2014 (UNESCO 2005a, b) have catalysed a debate on which competencies for sustainability in education future professionals should acquire and, hence, which ones should be worked on in universities (Aznar and Ull 2009; Barth 2007; Kraker et al. 2007; Sleurs 2008; UNESCO 2017).

Both the generic (common to any type of qualification) and specific (related to a particular field of knowledge) (Aznar and Ull 2009; UNESCO 2017) competencies for sustainability have been introduced into new degrees in a complex transition process in which both conceptual and methodological difficulties were encountered. On the one hand, there is the difficulty of understanding the competencies for sustainability, which is associated with the difficulty of understanding the concept of Education for Sustainable Development (ESD) (Wals 2009), and the concept of sustainability (Lozano 2008) including the integral view recommended in the preamble of the 2030 Agenda (UN 2015). On the other hand, the creation of the EHEA has meant a methodological change. It has gone from the traditional system of passing subjects by acquiring certain knowledge, to the assessment of learning results through competencies, which, in addition to knowledge, includes procedures, attitudes and values. This methodological change is bringing about a revolution in teaching and learning methods (Cano 2008) at universities, which, logically, also affects implementing sustainability in the curriculum of universities (Sterling 2004; Mulà et al. 2007; Tilbury and Wortman 2004; UNECE 2013; García-González et al. 2017).

According to the resolution of the UN General Assembly to declare a Decade of Education for Sustainable Development (2005–2014) "*Emphasizing* that education is an indispensable element for achieving sustainable development" (UN 2002), and to the *Education for Sustainable Development Goals: Learning Objectives* publication, education has a responsibility in promoting the right values and skills for implementing the SDGs (UNESCO 2017).

The University, as an institution dedicated to the creation and transmission of knowledge through research and teaching, plays a leading role in the diffusion and application of possible solutions and alternatives to the socio-environmental problems our current society faces (UNESCO 2005a, b; UN 2012). The challenge is for future professionals who must have competencies in sustainability to find solutions to the different global issues. "ESD can develop cross-cutting key competencies for sustainability that are relevant to all SDGs" (UNESCO 2017, p. 10).

After the Declaration of the Decade of Education for Sustainable Development (DESD) and the Declarations on Sustainability in Higher Education (Leal 2010; Lozano et al. 2013 and Michelsen 2016), efforts have been made to implement sustainability at University level (Albareda and Alférez 2016; Barrón et al. 2010; Calder and Clugston 2003; Disterheft et al. 2012; Ferrer-Balas et al. 2008; Geli and Leal 2006; Leal 2010, 2011, 2015a, b; Lozano 2009, 2011; Michelsen 2016; Müller-Christ et al. 2014; O'Byrne et al. 2015; Ramos et al. 2015; Wals 2014; Wals et al. 2016).

The challenge for universities to be more sustainable is complex. The preamble of the 2030 Agenda for SDGs (UN 2015), stresses the importance of working on SD from a holistic point of view: "We are committed to achieving sustainable development in its three dimensions -economic, social and environmental- in a balanced and integrated manner" (UN 2015). This integral and holistic view of sustainability is also present in ESD documents published at the beginning (UNESCO 2005a, b) and at the end of the DESD 2005–2014 Nagoya Declaration on Higher Education for Sustainable Development (UNESCO 2014a). In practice, however, much remains to be done.

Within the SUS, several universities are working on the implementation of sustainability in all areas of the university. The Conference of Rectors of Spanish Universities (CRUE in Spanish)[1] has two specific sectors, CRUE—Internationalization and Cooperation and CRUE—Sustainability, that work on sustainability. Both departments consist of different working groups that focus on the different areas. At the beginning of 2018, the Internationalization and Cooperation sector conducted a survey among all the SUS Universities on the knowledge and implementation of the 2030 Agenda for Sustainable Development at Spanish universities (CRUE 2018). With regard to the implementation of curricular sustainability, CRUE—Sustainability drafted and approved documents that propose core competencies in sustainability (CRUE 2012).

The content related to the SDGs includes the important social and environmental priorities worldwide, and the interconnections between them: No Poverty; Zero Hunger; Quality Education; Gender Equality; Clean Water and Sanitation, etc. The 2030 Agenda for Sustainable Development (UN 2015), including its 17 goals, offers universities a unique opportunity to meet their social obligations. "These goals combine efforts to eradicate poverty and increase the development of poor countries while decreasing the human footprint on the environment" (Saito et al. 2017).

The objective for implementing the SDGs in HE is to ensure graduates develop different competencies in sustainability: "competencies in systemic, anticipatory, and critical thinking" (Rieckmann 2012; Wiek et al. 2011), "competencies related

[1]CRUE is a non-profit organisation composed of 76 Spanish universities: 50 of which are public and 26 are private. It acts as the main interlocutor between universities and the central government and plays a key role in all the regulatory developments that affect higher education in Spain. For more information, visit the website: http://www.crue.org/SitePages/Inicio.aspx.

to ethics and values" (Barth et al. 2007; Rieckmann 2012; Sleurs et al. 2008; Wiek et al. 2011) and "interpersonal competencies" (Wiek et al. 2011). The implementation of the SDGs does not only require knowledge creation. It also requires a change in teaching methods, and in the methodological strategies linked to ESD (Albareda et al. 2018), including learning from real problems, anticipating and preparing for future sustainability challenges (Ryan and Tilbury 2013; Wiek et al. 2011), core methodologies, integrative thinking and practice including different disciplines, cultures and perspectives (UNECE 2011).

HEIs play a key role in the implementation of the 2030 Agenda of the United Nations, and developing competencies in sustainability at university level is a way to promote it. The challenge is to train university graduates to become competent in sustainability. In order to measure the students' level of sustainability and to verify the efficiency of the methodological scenarios allowing their implementation, an instrument like a competency map on sustainability is needed.

This paper presents, as the first part of the EDISNOST project, the process of drawing up the competency map on sustainability for education degrees. This competency map will be *operative*, that is, implementable in the different degrees in education and adopts an integral and *holistic* view of sustainability.

2 The EDINSOST Project

The EDINSOST project (Education and Social Innovation for Sustainability, in Spanish) is entitled: "Training professionals as change agents to meet the challenges of society in Spanish universities" and is funded by the "Programa Estatal de I + D+i Orientada a los Retos de la Sociedad" (RDI Government Programme directed towards societal challenges) from 1 January, 2016 to 31 December, 2018.

The overall objective of the project is to advance in education innovation for SD in universities, providing future graduates with the necessary competencies to initiate the change towards a more sustainable society.

To achieve the goal of the project, frameworks and processes that facilitate the holistic integration of ESD into the University curriculum will be developed. This will be done by mapping the existing pedagogical practices and frameworks in ESD, by making a diagnosis of the conditions of ESD in Spanish Universities and by creating and evaluating teaching and learning materials for students. Competencies in ESD will be developed for teachers by designing support materials and professional development courses.

The four specific objectives of the EDINSOST project are the following:

1. Define the sustainability map of the courses involved in the project and establish the framework that facilitates their holistic integration into the different degree programmes
2. Validate teaching strategies for the acquisition of sustainability from a pedagogical, constructivist and community approach

3. Diagnose the conditions of the sustainability training needs of the teaching staff, develop and test training proposals; and
4. Diagnose the conditions of sustainability learning for university students, develop and test training proposals.

The project involves a total of 15 degrees in the fields of education, business administration and engineering in 9 universities in Spain (UAM, UCA, UCJC, UCO, UdG, UIC, UPC, US and USAL), and 52 researchers between the research team and the work team. The 9 universities work together with the CRUE's Sustainability in the curriculum working group. This group assumes sustainability as a "concept that includes the pursuit of environmental quality, social justice and a fair and viable economy in the long run" (CRUE 2012).

The research methodology of the EDINSOST project is the interpretive approach, including quantitative and qualitative techniques that cover the three dimensions of SD: the social dimension of SD (education degrees), the environmental dimension (engineering degrees) and the economic dimension (business administration degrees).

On the one hand, three undergraduate degrees related to the three dimensions of sustainability (environmental, social and economic) are studied.

On the other hand, and taking into account their multiplier and long-term effect, special emphasis is placed on four undergraduate degrees and one master degree programme, since their graduates are the future teachers of the new generations of citizens.

Finally, seven technological degrees and a master degree in Sustainability Science and Technology will be studied because of their great impact on the challenges of society in the short-term.

The degrees on which the project will focus are:

– Undergraduate degrees: Pre-school Education, Primary Education, Pedagogy, Social Education, Environmental Sciences, Business Administration, Mechanical Engineering, Design Engineering, Electrical Engineering, Computer Engineering, Chemical Engineering and Architecture.
– Master degree: Science and Sustainability Technology and Environmental Education.

The results of the project will be promoted nationally through the Commission of the CRUE on Sustainability, and internationally through its plan of dissemination and transferability. An observatory on ESD and European Networks of HE in Sustainability will be created for this purpose (Sánchez et al. 2017).

3 Methods for Developing a Competency Map on Sustainability Degrees

As a starting point for integrating sustainability into the curriculum of the SUS, according to the CRUE (2012), four competencies in sustainability were identified that should work in all university degrees (generic or cross-curricular competencies).

The formulation of these competencies was expanded in the plenary session of the commission of the CRUE on Sustainability in Valencia on 9 March 2012, and was presented at the CRUE's General Assembly at the University of Girona on 28 June 2012. It was subsequently sent to all Spanish universities. The following cross-curricular competencies for sustainability are proposed for inclusion in university education (CRUE 2012):

- SUST 1. Competency in the critical contextualisation of knowledge through the linking of social, economic and environmental issues at a local and/or global level.
- SUST 2. Competency in the sustainable use of resources and in the prevention of negative impacts on natural and social environments.
- SUST 3. Competency to participate in community processes that promote sustainability.
- SUST 4. Competency to apply ethical principles related to sustainability values in personal and professional behaviour.

Sustainability competencies defined by the CRUE (2012), the rubric of generic competencies assessment, used for the evaluation of Service-Learning in the Faculty of Education of the UIC since 2009 (Fuertes 2014), and the work of the STEP group of the Computer Science Faculty at UPC were taken as a starting point for designing the competency map on sustainability. This group has been working on the design of a competency map on sustainability for computer engineering studies (Sánchez et al. 2016) since 2008. The convergence of the three projects mentioned above, which were partly produced by members of the EDINSOST project, has been the starting point for a competency map on sustainability. For this purpose, a structure based on 4 competencies related to sustainability was defined: SUST 1–SUST 4. Each competency is divided into three sustainability dimensions and, for each dimension, units of competency and levels, were defined using the levels of competency of the simplified Miller pyramid (Miller 1990).

Miller (1990) established a hierarchy of competencies in the medical profession (that can also be applied to other professions), which are depicted in Fig. 1.

From the selection of competencies and the hierarchy of results established by Miller (1990), the study focuses on analysing what the learning outcomes allow us to evaluate. It established three levels of acquisition defined by learning outcomes (indicators), based on the standards set by the National Centre for Education Statistics (NCES) (2002). The first level domain corresponds to knowledge and refers to "learning", the second level domain corresponds to integration and development in the situation and finally, the third level domain is linked to demonstrating competency in the action and the possibility of transferring this action.

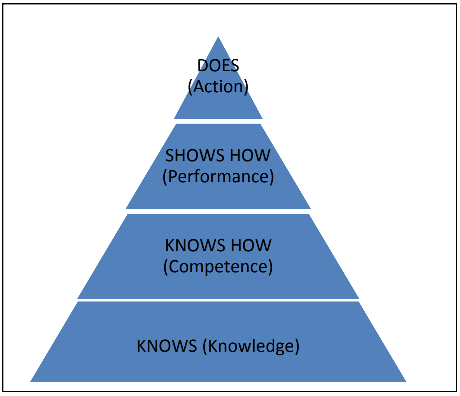

Fig. 1 Miller's Pyramid (1990) *Source* Author's adaptation of various versions of Miller's Pyramid

Drawing up a competency map on sustainability for several education degrees was an arduous and complex process. Therefore, it was decided to elaborate a work of simplification focusing on the holistic view of sustainability in the SDGs (UN 2015) and thus concentrating only on the holistic view of every competency. The work was organised per degree. The degree programmes that were part of the project were the following: Pre-school Education, Primary Education, Pedagogy and the master degree in Environmental Education.

This work method per degree programme consisted of three phases and took place during academic year 2016–2017:

1st phase: Compilation:

In this phase, all the generic competencies were associated with the degree reports[2] of the 8 universities, including the competencies in sustainability of the CRUE (2012). Those competencies were reviewed for international reports of competencies in sustainability and International Professional Standards for Teachers (AITSL 2016; Sleurs 2008; UNECE 2013; UNECE 2016; UNESCO 2017). Each degree programme from each university had its own map of competencies based on an analysis of the curriculum included in the official documents of university degrees and the degree reports elaborated by the CRUE. In almost all competencies, each of the dimensions of sustainability and their corresponding holistic view was considered. 19 different maps were drawn up in total. This first phase intended to be as exhaustive as possible without leaving out any cross-cutting core competency for sustainability or SDGs aspect.

2nd phase: Compilation per university and degree:

Once the 19 competency maps were completed, synthesis and compilation were performed per degree and postgraduate course, with the aim of obtaining a single map of competencies for the education degrees. In this phase, five final maps of

[2]The degree reports are official documents of University degrees, presented by each University and approved by the Spanish National Agency for Quality Evaluation and Accreditation (ANECA).

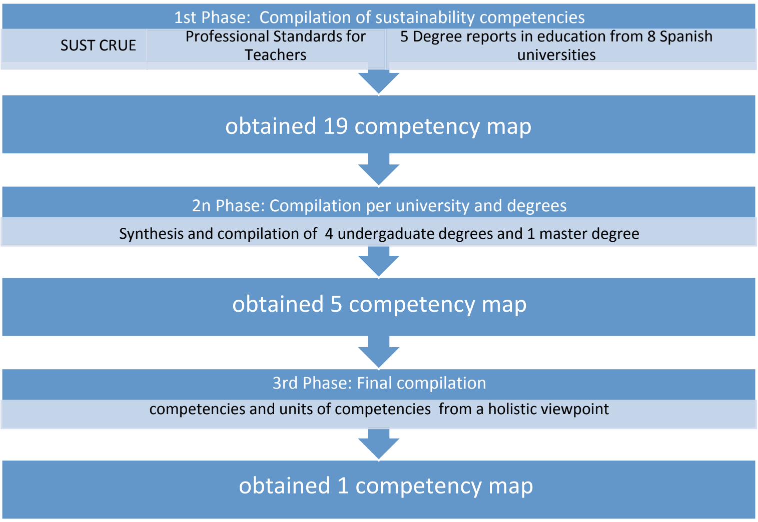

Fig. 2 Methodological sequence for the elaboration of a competency map on sustainability *Source* Own work

education were obtained, corresponding to 4 undergraduate degrees and 1 master degree.

First, we discussed and agreed on introducing the specific competencies in accordance with the degree programmes, an idea that was nuanced in the second phase. We then analysed the contributions of each university in the different degree programmes to obtain complete findings, not only a sum of specific contributions. Finally, it was decided to consider only the four general competencies initially established.

3rd phase: Compilation to obtain a single map of competencies.

The purpose was to obtain a simple operational and finished instrument that would be useful for all education studies. From the map of 5 competencies (4 undergraduate degrees and a master degree), a synthesis effort was made, which entailed an intense debate between the coordinators of the different education degrees.

This last phase of compilation meant perfecting the units of competencies. We decided to consider all of them from a holistic viewpoint, integrating the three dimensions of sustainability, as recommended in the 2030 Agenda (UN 2015). We characterised these units of competency according to the domain levels: knowing, knowing how, demonstrating and doing, thus adapting the initial scheme of the Miller pyramid.

Figure 2 shows the methodological process used to elaborate a single map of competencies.

4 Results and Discussion

There have been numerous attempts to make compilations of core competencies in sustainability in HE, both in sustainability in general and in ESD.

The understanding of sustainability and competencies for sustainability at universities is sufficiently deep and complex to analyse the concept of competency, the concept of sustainability and the competencies in sustainability further. Implementing the proposals of the EHEA has at least led European universities to work on competencies and they are reflected in the curriculum for each degree. The difficulty lies in assessing the competencies from the learning results of the students.

This paper presents the first result of the EDINSOST project: a competency map on sustainability for 4 undergraduate education degrees (Primary Education, Pre-school Education, Pedagogy and Social Education) and a master degree in Environmental Education, offered at eight Spanish universities. The map is easily adaptable to any education degree and to other HE degrees.

Table 1 contains the Competency Map on Sustainability in Education at University level.

This table allowed us to face the different objectives of the project. It implied looking closely at the syllabi of the subjects of the different degrees in education to analyse which competencies are being developed and how they are progressing.

It enabled us to analyse the presence of competencies in the curriculum of the different education degrees considered (Objective 1); to validate the most suitable didactic strategies to develop these competencies in sustainability (Objective 2); to diagnose the current situation of teachers with respect to developing didactic strategies for sustainability (Objective 3); to carry out a diagnosis on the students' situation regarding learning about sustainability in their degree programme (Objective 4).

The overall objective of the project is to advance in education innovation in ESD in universities, providing future graduates with the necessary competencies to initiate the change towards a more sustainable society. This is a challenge for university instructors when designing activities and strategies that enable their students to acquire competencies in sustainability (Molderez and Fonseca 2017).

In the map of competencies, discussions external to scientific education are linked with practices in the field of education (Brundiers et al. 2010), promoting the existence of science and technology that goes beyond the vision as the solver of the problems, recognizing its uncertainties and limitations. This implies moving away from a narrow and neutral idea of the development of HE, recognizing that the course of development of our planet is marked by a society full of political, economic, cultural and environmental imbalances (Medir et al. 2016).

The map provides six units of competencies with three domain levels (Miller 1990; NCES 2002), which describe the phases so that future educators can become competent in dealing with sustainability. On the map for education degrees, acquiring competencies begins with the understanding of the natural, social and economic systems and their interrelations, both at a global and local level.

Table 1 Competency map on sustainability in education at university level

SUST competency map of all the degrees in education					
Related competencies	Dimension	Competency unit	Domain levels (according to the simplified miller pyramid)		
			Level 1. Knowing	Level 2. Knowing how	Level 3. Showing and doing
SUST 1- Critical contextualization of knowledge establishing interrelationships between social, economic and environmental, logal and/or global problems	Holistic	1.1. Understands the functioning of natural, social and economic systems, as well as their interrelations and problems, both at a local and global level	Knows the functioning of natural, social and economic systems and the mutual relations between them	Analyses and understands the relationship between natural systems and social and economic systems	Is able to imagine and predict the impacts the changes produced in natural systems may cause in social and economic systems and among each other
		1.2. Possesses critical thinking and creativity, taking advantage of the different opportunities presented (ICT, strategic plans, regulations, etc.) in the planning of a sustainable future	Knows the procedures and resources to integrate sustainability into educational projects	Understands and takes advantage of the opportunities that present themselves in educational contexts in order to plan sustainable projects	Provides solutions to educational projects from a critical and creative viewpoint with the aim of planning a sustainable future
SUST 2 Sustainable use of resources in the prevention of negative impacts on natural and social environments	Holistic	2.1. Designs and develops actions, making decisions that take into account the environmental, economic, social, cultural and educational impacts so as to improve sustainability	Has basic knowledge of identifying possible socio-environmental impacts derived from educational actions	Knows how to develop educational actions that mitigate negative socio-environmental impacts	Designs and develops educational activities in which negative socio-environmental impacts are taken into account and incorporates mitigating measures

(continued)

Table 1 (continued)

SUST competency map of all the degrees in education					
Related competencies	Dimension	Competency unit	Domain levels (according to the simplified miller pyramid)		
			Level 1. Knowing	Level 2. Knowing how	Level 3. Showing and doing
SUST 3- Participation in community processes that promote sustainability	Holistic	3.1. Promotes and participates in community activities that encourage sustainability	Recognises himself/ herself as an integral part of his/ her surroundings and knows the community education programmes that encourage participation and commitment to socio-environmental improvement	Is able to interact satisfactorily in education community projects, encouraging participation	Designs and carries out socio-educational activities in participatory community processes that promote sustainability
SUST 4- Application of ethical principles related to sustainability values in personal and professional behaviour	Holistic	4.1. Is consistent in actions, respecting and valuing (biological social and cultural) diversity and commuted to improving sustainability	Knows the ethical principles of sustainability and the importance of respecting diversity in educational intervention	Understands and integrates the ethical principles of sustainability in his/ her actions, considering nature as a good in itself and transmuting the importance of education for a change in the relationship between human beings and the socio-cultural environment	Is able to design and/or manage educational projects taking into account ecological ethics to improve quality of life and to promote the common good

(continued)

Table 1 (continued)

SUST competency map of all the degrees in education					
Related competencies	Dimension	Competency unit	Domain levels (according to the simplified miller pyramid)		
			Level 1. Knowing	Level 2. Knowing how	Level 3. Showing and doing
		4.2. Promotes education in values oriented to the formation of responsible, active and democratic citizens	Takes into account promoting integral and sustainable human development as the basic purpose of the formation of citizenship	Critically analyses and assesses the consequences his/her personal and professional actions may have on the integral development of students and on promoting sustainable human development	Designs and develops educational intervention proposals that integrate the values of sustainability and which result in justice and the common good

With regard to critical thinking, designing and developing actions that take into account the environmental, economic, social, cultural and educational impacts (Barth et al. 2007; Wiek et al. 2011). In the same way, the competency map shows the importance of teachers promoting values oriented towards the formation of responsible, active and democratic citizens.

The challenge is to train future university graduates to be competent in sustainability, even knowing that the implementation of sustainability at universities has encountered several barriers (Albareda et al. 2017; De Kraker et al. 2007; Thomas 2016; Weik et al. 2011). The competency map intends to be an instrument for implementing the SDGs at University level and to help educators be competent in sustainability.

5 Conclusions

The conclusions are derived from the objective to elaborate a map of sustainability competencies to analyse the level of inclusion of these competencies in different degrees in education.

Defining competencies allows us to create the appropriate work framework to later be able to validate teaching strategies, to detect teacher training needs and to analyse the conditions and forms of the students' learning process that promotes the inclusion of general competencies in sustainability.

This project has allowed us to see the relevance of defining units and domain levels of competency in sustainability in order to evaluate the integration of these competencies into the curriculum. It also shows the relationship between competencies, objectives and teaching methodologies.

The map is directly adaptable to each of the degrees involved. It takes a holistic view and contains three domain levels for each competency.

The map of competencies presented is designed in such a way that it allows integrating knowledge, attitudes and values, in harmony with a sustainable future. Participation in community processes, critical thinking, understanding of the functioning of society, educational actions, etc. are some of the indicators that allow us to organise the competencies in sustainability into units. All of them reveal education in values is necessary in order to form a responsible and committed citizenship. It is the only way students will understand the nature of their behaviour, so as to improve and reorient their future professional achievement towards valuable options for them, for the people around them and for the environment.

Future graduates will not be competent in sustainability only because some knowledge related to the serious problems the planet suffers and its socioeconomic consequences has been transmitted to them. They will because they have been able to design new work frameworks in which they find the real-life problems they intend to solve. Therefore, in addition to designing a competency map on sustainability that can serve as a rubric in the evaluation process, it is advisable to develop methodological strategies that enable the development of these competencies.

The work set out in this paper on the design of a competency map on sustainability for education degrees presents certain limitations. The EDINSOST project considers more objectives. However, drawing up a competency map on sustainability for degrees in the field of education as a starting point is a key finding as an evaluation tool that allows us to speed up the process of incorporating the principles and guidelines for SD in the university curriculum.

Characterising the domain level of the acquisition of competencies in sustainability is key to analyse the extent to which the strategies, procedures and methodologies in general teaching and learning are appropriate for the contribution to sustainability and SD in HE. In order to promote a sense of universal responsibility in citizens, as recommended by the 2030 Agenda, the commitment of the educational system to ESD is essential, and the degrees in education are key for this purpose.

The most relevant conclusion is that this study contributes to the debate on the concept of competencies in sustainability in universities and in particular, in the EHEA, since both sustainability and development of competencies are new concepts and even more so in university teaching. The review of academic literature on competencies in sustainability and their compilation, performed in the present study, aim to contribute to conceptual clarification.

Finally, this paper, which includes a compilation of competencies in sustainability may serve as a reference for the evaluation of other researchers and teachers in the field of sustainability.

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Environmental DNA (eDNA) Metabarcoding as a Sustainable Tool of Coastal Biodiversity Assessment

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Abstract Global biodiversity loss represents one of the most serious environmental crises of the 21st centuries, with substantial impact on both ecosystem services and the health of our environment. 52% of global biodiversity decline was recorded between 1970 and 2010, and this loss was even higher for freshwater populations than for marine or terrestrial ecosystems (WWF 2014). Undeniably, Malaysian coastal ecosystem harbour extraordinary biodiversity having this country is recognised as one of the megadiverse country. However, unsustainable development of the Malaysian coastal area has led to the decline of the aquatic biodiversity. There is limited knowledge on the extent of biodiversity and the genetic resources in the aquatic environment some of them could already be extinct before we could identify them. Therefore, by implementing the Living Lab concept accustomed to the university, a non-invasive alternative method called environmental DNA or eDNA metabarcoding with an aid of Next Generation Sequencing (NGS) was introduced to identify species diversity of fish in a coastal ecosystem. In this study, the eDNA metabarcoding tool is applied in assessing water samples for fish species detection. This new, time and cost-effective method enables the acquisition of large datasets, paving the way for a finer understanding of fish diversity in different river landscape, with major implications for sustainable fisheries management and conservation, in parallel to goal fourteen (14) of the United Nations Sustainable Development Goals—Life Below Water.

Keywords Biodiversity · Environmental DNA (eDNA) · Sustainable tool · Metabarcoding

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1 Introduction

Biodiversity epitomizes the diversity of different organisms with their functions and relationship within an ecosystem. In order to understand the biodiversity of a certain ecosystem, assessments are crucial in recognizing the key components of the ecosystem. Biodiversity assessments or surveys are critical to monitor and assess the health of ecosystems and the species within them. Biodiversity assessment usually is done using conventional identification methods which involves classifying morphological characters and utilizing taxonomic keys for species identification. The morphology-based biodiversity assessment can be invasive, time consuming and financially expensive. Additionally, the limitation of experienced taxonomist and a proper developed species identification keys are the major challenges in this method of assessment. It is impossible to develop conservation plans and long-term management of an ecosystem without knowing what species are involved.

Anthropogenic disturbances are causing ongoing decline in biodiversity globally (Schmeller et al. 2017). In the past five centuries, human-driven global change has started the sixth mass extinction, which is more severe than the previously feared and massive five mass extinctions recorded in Earth's history (Barnosky et al. 2011). The rapid loss of biodiversity that has occurred primarily affecting both human health and the sustainable future of the planet. Within the last century, the rate of global biodiversity continues to decline significantly with this loss being greatest in freshwater ecosystems despite efforts to prevent such loss (Collen et al. 2014; Turak et al. 2016). In order to prevent further declines, many jurisdictions have enacted regulation to protect species at risk and their habitats. This is being done through collecting information regarding the species distribution, diversity and biology through regular biological monitoring.

Presently, there are several commonly practiced biological monitoring methods which apply specific designed for a specific group of organisms which includes combination of both observational and invasive capture methods. However, these methods of assessments were restricted by high cost, time consuming and limited number of trained labour (Darling and Mahon 2011). Likewise, the invasive nature of the conventional capture-based surveys will increase the probability of predation risk to the organism despite probably damaging the entire ecosystem (Shaw et al. 2017). Furthermore, an ongoing decrease in the number of taxonomic expertise and the non-standardised skill levels of different taxonomist may also hinder the traditional morphological identification-based methodologies despite might introducing bias in the assessment (Shaw et al. 2016).

Existing biodiversity assessment methods require improvement in order to monitor and protect the whole biodiversity in general especially for the future of freshwater biodiversity and resources. In turn to bear the improvement, more detailed, extensive and rapid surveys are crucial. Nevertheless, such advances cannot be made without increasing the costs and input time with effort in the conventional methods. Hence, a new, time and cost-effective tool has to be developed in order to support the lim-

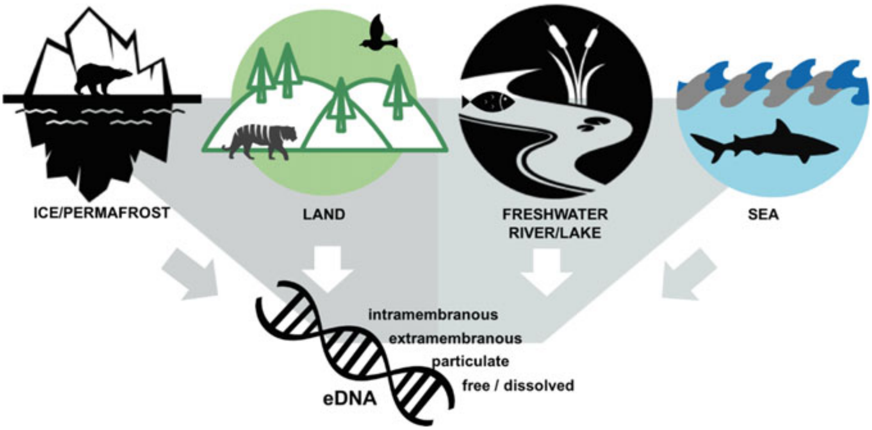

Fig. 1 Potential environments where presence of eDNA has been reported. Environmental DNA (eDNA) has been reported based on successful extraction and characterisation from basal glacier ice, terrestrial sediments, lake, rivers and lake sediments, and ocean water. Hypothetically, the eDNA came from animals' faeces, urine, epithelial cells, eggs, sperm, plants' pollen grains and other plant and animal associated micro- and macro- fossils and organisms that may be present extra-cellularly and/or intra-cellularly. Adapted and modified from Pedersen et al. (2015). Images were retrieved and modified from free-access and non-licenced Google images

itations of the conventional biodiversity assessment and provide enough taxonomic resolution using the new method.

The biodiversity assessment is the core aspect of conservation biology. Environmental metabarcoding is a tool used in species detection in the assessment with very minimal impact to the surrounding environment (Schnell et al. 2012; Bohmann et al. 2014). Metabarcoding is a relatively new molecular method that is used in characterising biological taxa from DNA within an environmental sample (Taberlet et al. 2012). While the concept of DNA barcoding in taxa identification is well established, the use of environmental DNA (eDNA) starts to gain popularity from its effectiveness in identifying taxa from environmental samples in bulk. DNA barcoding characterised short fragments of DNA that serve to identify a taxon or even to species level by comparing the standardised fragment to a reference database (Hebert et al. 2003). Environmental DNA (eDNA) metabarcoding extends the concept of DNA barcoding by analysing environmental samples to determine the species composition within a sample. Environmental DNA (eDNA) mixtures can consist of DNA from multiple taxa of all life stages, such as vertebrates, invertebrates, bacteria or algae, from a wide variety of sample types such as sediments, soil, faeces or marine and fresh waters (Fig. 1) (Taberlet et al. 2012).

2 University as Living Labs: Efforts in Revolutionising Biodiversity Assessment for Sustainable Development

The idea of a university as a Living Lab were firstly introduced in the early 2000s (Van Geenhuizen 2013). As for any emerging sustainability concept, many preliminary or pilot research reports have been published thus far, as well as many reviews highlighting the potential of the Living Lab concept in sustainable development (Evans and Karoven 2011; Dell'Era and Landoni 2014; Evans et al. 2015). Living Lab concept can be described as an ecosystem that catalyse action and collaboration in developing innovation. Living Lab concept has started to be practiced in Universiti Sains Malaysia (USM) recently, with the implementation of various knowledge transfer programs and holistic academic syllabus that focusing on sustainable development and conservation of the ecosystem. USM tries to combat global sustainability-related crisis by providing guidance and answer to students, staffs and academics through advance research infrastructures and practices. The Living Lab concept in USM also offers opportunities to all university stakeholders, researchers, industry, and policy makers to collaborate in initiating high-impact research and innovation for the sustainable development of socio-cultural and economic.

USM realizes that the sustainability challenges are new and emerging and there is an urgent need to develop a new approach in tackling these circumstances. Through facilitating research, global environment situation, such as the challenges in documenting biodiversity and assessing environment health can be solved by developing practical solutions and embracing the digital technologies advancement. By utilising the existing and newly generated qualitative and quantitative data, refine solutions to these environment issues can be proposed. Collaborative Living Lab projects with multiple researchers, government agencies and natural resource managers would definitely enable more opportunities of initiating impactful research and catalyse sustainable innovation. For instance, with collaboration of USM's researchers, students and a government agency—Fisheries Research Institute (FRI), Malaysia, a pilot study has been proposed with a specific goal to develop a sustainable and cost-effective method in assessing fish diversity in selected ecosystem utilising the environmental DNA (eDNA) metabarcoding technique. Through the Living Lab concept, conventional method of biodiversity surveys can be revolutionised, and these advances will enable researchers and natural resource managers to better understand, manage, and conserve biodiversity globally.

3 eDNA Metabarcoding as a Sustainable Tool of Biodiversity Surveys

Routine biological surveys are crucial in managing the species population and monitoring the aquatic ecosystem especially in the important coastal environment. Netting approaches in capture-based method of biological surveys are invasive to the natural ecosystem while increasing stress and predation risk to the animals itself (Rottmann et al. 1992). Fish survey in natural aquatic ecosystem covers multiple components which includes estimating the total area of the habitat, total fish numbers, and species composition (including identifying introduced species) (Hankin and Reeves 1988). In Malaysia specifically, there are a variety of methods that is used to sample fish in the coastal area which includes the rivers, streams and estuaries. Gill net, hook-and-line, bag net, trammel net, lift net, traps, dip net, hyke net, angling, visual census and electrofishing are the most common methods in conducting fish surveys (Fisheries 2011). While these common methods are traditionally used, the molecular approach has revolutionised a pathway by using environmental DNA (eDNA). Application of eDNA metabarcoding for biodiversity assessments/surveys has gained much attention because of its efficiency in ecosystem biomonitoring. A comprehensive monitoring program should account for knowledge of a species' distribution, their habitat and allowing adaptive management to be practiced. One of the earliest, successful eDNA surveys utilising water samples is done by Ficetola et al. (2008) where they utilise eDNA in detecting invasive species of the bullfrog, *Rana catesbeiana* in natural wetland ponds for the purpose of biomonitoring. This study marks the novel application of eDNA in conservation genetics to document occurrences of aquatic invasive species.

Environmental DNA (eDNA) has effectively detects the presence of fish species in both freshwater and marine ecosystem (Bohmann et al. 2014; Rees et al. 2014). Recent studies also have shown that eDNA is far more sensitive in detecting rare or uncommon species as compared to capture-based survey methods (Jerde et al. 2013; Laramie et al. 2015) and several researches have proven that eDNA is useful for detecting species that would be difficult to find using traditional methods due to either low density or trap shyness (Shaw et al. 2016; Simpfendorfer et al. 2016). Environmental DNA (eDNA) surveillance is not only essential for detection of invasive species but can also be useful in the discovery of endangered species. Research utilising eDNA in the field of endangered species has shown positive detection of both amphibians (Dejean et al. 2012; Ficetola et al. 2008; Pilliod et al. 2013; Rees et al. 2014) and freshwater fishes (Bylemans et al. 2017; Eva et al. 2016). A summary of several applications of eDNA in biodiversity monitoring, specifically in fish surveys is presented in Table 1.

4 General Methodologies of eDNA Metabarcoding

Generally, eDNA metabarcoding approach of biodiversity assessment begin with the collection of environment sample, extracting the DNA within the environmental sample, and developing a DNA library that either comprises of a random subset of the DNA present (by using shortgun sequencing) or targets specific and informative DNA fragments (amplicon sequencing) (Shaw et al. 2017). Next Generation Sequencing (NGS) platforms were then being used in generating the DNA sequences before the sequence reads is run through the bioinformatics analyses in taxonomic identification

Table 1 Some of the major findings in application of eDNA in biodiversity monitoring, specifically in fish detections

Source of sample/environment	Application	Study summary	References
Fresh water/stream	Species detection and distribution	The study utilizes eDNA in detecting Arctic grayling in Missouri River basin	Carim et al. (2016)
Fresh water/pond	Species detection	The study is conducted to test eDNA persistence in water in order to confirm the presence of the focus species (Siberian sturgeon and Bullfrog tadpoles in freshwater ecosystems)	Dejean et al. (2011)
Fresh water/mesocosms	Species abundance quantification	The study determines whether environmental DNA (eDNA) sampling and metabarcoding analysis can be used to accurately measure species diversity (freshwater fishes and amphibians) in aquatic assemblages with differing structures	Evans et al. (2016)
Fresh water/natural lake	Invasive/rare species detection	This study discovers the use of eDNA in Asian Carp detection and promotes the implementation of eDNA in effective and sustainable surveillance program for invasive/rare species	Jerde et al. (2013)

(continued)

Table 1 (continued)

Source of sample/environment	Application	Study summary	References
Sea water/mesocosms	Multiple species detection	Fish community-wide assessment in marine environment using eDNA metabarcoding	Kelly et al. (2014)
Fresh water/river	Species detection and distribution	The study reveals the effectiveness of eDNA detection methods for determining landscape-level distribution of anadromous salmonids in large river systems	Laramie et al. (2015)
Fresh water/river-estuary	Multiple species detection	The study utilizes eDNA in temporal mapping of marine and freshwater fish populations	Stoeckle et al. (2017)
Fresh water/pond	Invasive/rare species detection and distribution	The study utilised eDNA in detecting the presence of invasive bluegill in natural ponds of the studies area	Takahara et al. (2013)
Sea water/ocean	Multiple species detection	The study demonstrates the potential of eDNA in biodiversity monitoring and fisheries as compared to conventional methods	Thomsen et al. (2012a)
Fresh water/mesocosms	Species abundance quantification	This study discovers the use of eDNA in fish and amphibians' detection in freshwater mesocosms	Thomsen et al. (2012b)

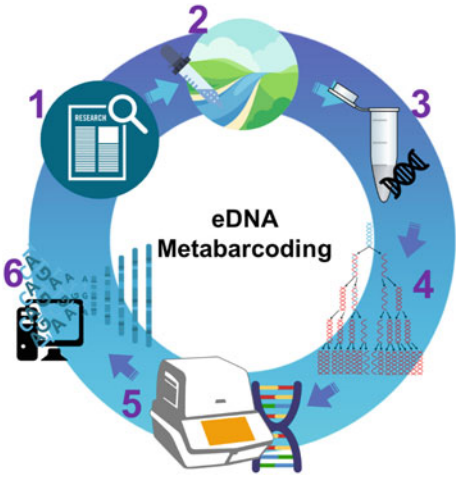

Fig. 2 The fundamental pipeline of an eDNA metabarcoding for biodiversity survey. (1) Research question is being identified in order to develop a proper experimental design. (2) Environmental samples are being collected from the studied site. (3) DNA is extracted from the environmental sample using conventional or commercial extraction kit. (4) The target gene region (selected genetic marker) is amplified by PCR by using tagged primers. (5) Multiple samples are pooled before parallel sequencing is done using NGS platform. (6) Sequences generated by the NGS platform is run through bioinformatics analyses in assigning MOTUs. Images were retrieved and modified from free-access and non-licenced Google images

by comparing them to the developed genetic reference databases. In this particular study, in order to identify fish diversity in a coastal ecosystem which includes an estuary and different landscapes of streams and rivers, three replicates of 1L of the fresh/brackish water are collected from multiple sampling points across the river and estuary. The water samples were immediately filtered using a sterile capsule filter before being dried and stored with silica beads that serve as a desiccator, preventing the DNA from degrading. The sample filters were then stored at −20 °C until extraction. DNA extraction were then performed using a commercial DNA extraction kit following the manufacture's protocol. Purified extracts were then assessed for DNA concentration using DNA spectrophotometer. In the next step, DNA is amplified using the selected metabarcoding primers' set. Commonly, a universal, validated primer set such as MiFishU (Miya et al. 2015) is used in identifying marine and freshwater fishes in such project. Generated amplicons were then being tagged and pooled before the NGS library is being developed. The sequences produced from the NGS platform were then being analysed using multiple bioinformatics tools in delimiting the MOTUs and taxonomic clustering. Figure 2 illustrates the simplified visualisation of the general methodologies of eDNA metabarcoding.

5 Integrating eDNA Metabarcoding in Intensive Coastal Biodiversity Assessment

The Sustainable Development Goals or SDGs was formally adopted in September 2015 and it addresses the three inter-related elements of sustainable development, they are, economic, growth social inclusion and environmental sustainability. Parallel to this goal, this research will address SDG 14 which is life below water. One of the many challenges to achieving Agenda 2030 is how do we work across these three elements in order to achieve sustainable development. For this purpose, we are relating this study of eDNA metabarcoding as a method to expose sustainable practice of coastal biodiversity assessment.

As mentioned earlier, the coastal ecosystems are under a lot of pressure from anthropogenic stressors including climate change, pollution and overexploitation (WWF 2014). As a result, health degradation in freshwater and marine ecosystem globally is observed, especially in terms of biodiversity loss (Butchart et al. 2010), species invasions (Strayer et al. 2006) and water quality (Foley et al. 2005). Traditional diversity sampling methods for coastal biodiversity assessment include nets, visual observation, hooks and lines and many more could prove to be a disaster to many sensitive taxa. In many countries, monitoring commercially important fish stocks are done by using bottom trawl surveys to get data for fish abundance, their distribution and diversity. Much to disappointment, these bottom trawlers damage the marine environment and slowly it will have detrimental effect on the fishing industries. This will have negative impacts to the livelihood and the socio-economics of the people who depend on it. Therefore, sustainable method in the monitoring and management is required in sustaining the health of the ecosystem.

Under the implementation of the university as a Living Lab, the eDNA metabarcoding method is proposed to be a new technique in achieving large-scale species diversity acquisition without harming the environment. This method will stress on the important of SDG 14—life below water in highlighting the importance of species documentation in order to assess the health and socio-economics value of an ecosystem, especially in sustainable fisheries management and conservation to achieve food security. This is imperative because in 2013, fish accounted for about 17% of the global population's intake of animal protein and 6.7% of all protein consumed and global total of capture fishery production in 2014 was 93.4 million tonnes, of which 81.5 million tonnes from marine waters and 11.9 million tonnes from inland waters (FAO 2016). Therefore, species documentation is necessary in keeping track of biodiversity values and resources to a country's social and economic development. The eDNA metabarcoding methods can speed up species documentation by building an inventory for species diversity and it is able to catalogue and map species distribution and associations, indirectly, linking these habitat distributions with the natural and anthropogenic processes influencing them.

Recently, a large scale eDNA metabarcoding study was done by looking at vertebrate biodiversity in Monterey Bay, California (Closek et al. 2016). The fluctuation of dominance between *Sardinops sagax*, pacific sardine and *Engraulis mordax*, northern anchovy has been documented in the California Coastal Ecosystem for more than 100 years and these two species are some strong drivers of trophic interactions in the region. In the experiment that was done over a span of eight years (2008–2015), collecting sea water, they found that more than 20 fish genera were detected in the area where *Engraulis mordax* served as the dominant fish. Both *Engraulis mordax* and *Megaptera novaeangliae*, humpback whale was also detected present in temporal patterns and this is similar to visual observations reported during the years from 2013 to 2015 compared to other years. This study is important because it establishes a building capacity in biodiversity monitoring at the global scale using eDNA method.

The application of eDNA metabarcoding was also successful in an assessment done in Coral Bay, Australia. In this study they focused on assessing the broad potential of eDNA for auditing marine taxa and successfully analysed over 23 million sequences originating from 9L of filtered seawater. Using metabarcoding, data was successfully assigned to 434 eukaryotic taxa (from the kingdom Animalia to Protozoa) with 38 phyla, 88 classes, 186 orders and 287 families (Stat et al. 2017).

As this method can update species inventory from time to time, it can also be applied as an early detection system in the detection of invasive species before it spread and reduce the biodiversity of a certain area. For example, the invasion of two species of Asian silver carp, *Hypophthalmichthys molitrix* and the bighead carp, *Hypophthalmichthys nobilis* in the the Missouri and Mississippi River systems (Klymus et al. 2015). By focusing on eDNA method, they were able to detect the early presence of the two invasive species, locate their habitat and estimate the biomass and timing as well as location of spawning events. Therefore, this can help in the management and conservation of the river.

Examples of above studies were some of the benefit of eDNA metabarcoding in highlighting species biomonitoring of many taxa. All of the studies were able to provide the fundamental for a practical large-scale monitoring program operating across the full range of commercialise, endangered, cryptic and invasive species for sustainable management and conservation of coastal ecosystem.

6 Challenges of eDNA Metabarcoding in Operational Biodiversity Research and Monitoring

Over this last decade, tremendous effort has been made toward implementation of sustainable development in managing the biodiversity and conserving the ecosystem. Environmental DNA (eDNA) metabarcoding has the potential to provide massive resource of biodiversity inventory, but it has its limitation. One of the challenges is the requirement of multiple and disparate skills. However, this limitation can be solved by the implementation of the Living Lab concepts by the organisation conducting the project. The Living Lab concepts enable the ecosystem manager to have a platform in exchanging resources and expertise. If being applied in an academic institution, for instance in a university, students and managers can be trained to effectively integrate this tool into academic and operational biodiversity research and monitoring. Undoubtedly, with the proper implementation, eDNA metabarcoding will become the key solution of sustainable biodiversity assessment in the near future.

7 Conclusion

Biodiversity assessment do take up a lot of time and resources for example, budget and skilled labour, thus it may impede conservation effort especially with the current rapid rate of loss of biodiversity. Addressing this issue, by the implementation of the Living Lab concept, the eDNA metabarcoding method is proposed to contribute in rapid assessment of biological diversity so preservation and management of ecosystems can begin early. The advances of eDNA analyses has developed a sustainable tool that can assist ecosystem managers in assessing the diversity and distribution of fishes. Environmental DNA should be applied as a time and cost-effective bioassessment tool that can complement the conventional method of biological surveys. These advances will enable researchers and natural resource managers to better understand, manage, and conserve global biodiversity. Carrying through the Living Lab concept, specifically by the university, collaborative effort among academics, researchers, students, and ecosystem managers could be reinforced to apply the newly proposed sustainable method in assessing biodiversity in a larger scale and even in a different ecosystem.

Glossary

Amplicon	A fragment of DNA or RNA derived from replication process or amplification, either naturally or artificially, through for example a PCR process.
Biomonitoring	Biodiversity assessment that is done in repeats across space and time that may focus on a target organism such as invasive or at-risk species.
DNA Barcoding	The use of a short, standardised DNA fragments in taxonomic identification by comparing the DNA sequence to a reference database.

DNA Sequencing	A process whereby the order of nucleotides within a DNA sequence is determined.
Environmental DNA (eDNA)	Trace of DNA in environmental samples—water, soil or faeces. eDNA is a mixture of potentially degraded DNA from many different organisms and be in different physical states (intraorganismal, intramembranous, particulate, adsorbed or free) (Taberlet et al. 2012).
Marker	A gene or a region of DNA with a known location in the genome and can utilised in identifying individuals or species.
Metabarcoding	identification of taxon from DNA extracted from a sample containing many different organisms.
Molecular Operational Taxonomic Unit (MOTU)	The working proxy for "species" in molecular ecology. It is the taxonomic level of sampling defined by the researcher in a study. MOTUs are generated by comparing sequences against each other to form a distance matrix, followed by clustering groups of sequences with a specified amount of variability allowed within each MOTU (Bohmann et al. 2014).
Next Generation Sequencing	Parallel sequencing technologies which produce thousands to billions of DNA sequences in a single sequencing run—e.g. Illumina Genome Analyser Series, Roche 454, Life Technologies SOLiD, Ion Torrent and PacBio.
PCR	Polymerase chain reaction is a method used to amplify a single copy or a few copies of a fragment of DNA generating thousands to millions of copies of a particular DNA sequence.

Primers	Short oligonucleotides that are complimentary to a particular region of the genome and are the starting point of DNA replication in PCR process.
Taxon	An organism identified to any taxonomic rank; from kingdom to species level.

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Visual Displays of the Sustainable Development Goals in the Curricular and Extra-Curricular Activities at Nottingham Trent University—A Case Study

Vanessa Odell, Petra Molthan-Hill, Lina Erlandsson and Eleanor Sexton

Abstract The United Nations' Sustainable Development Goals (SDGs) have been fully embedded into the formal and informal curriculum of Nottingham Trent University (NTU), United Kingdom. In order that staff and students can recognize the 17 goals and 169 targets, visual displays have been used to act as cues and content providers in curricular and extra-curricular activities. This paper summarizes the different approaches taken to display the SDGs visually at NTU. All taught courses/programmes at the university address at least one of the SDGs and have the option to include their chosen SDG as an icon in both physical and digital course materials. Extra-curricular activities include the creation of thought-provoking installations of the goals around the estate, for example demonstrating the vast amount of plastic bottle waste contributing to ocean marine debris (SDG 14, target 1) linked holistically to competitions and workshop activities targeted at raising insights of staff and students and changing behaviour. This paper will offer detailed descriptions of the displays created at NTU, for example as part of Green Week and how these can be easily replicated at other universities. The paper will, therefore, be of interest to anyone aiming to adopt visual approaches to communicating sustainability messages in curricular and extra-curricular activities.

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1 Introduction

The purpose of this chapter is to give new and significant insight into the use of visual aids to engage staff and students with the United Nations Sustainable Development Goals (SDGs) in the curriculum and extra-curricular activities carried out at Nottingham Trent University (NTU). Using extra-curricular visual displays, is both a dynamic and delightful way to raise awareness, contrasting the traditional style of having a stall which allows learning to be extended outside of the classroom. Visual aids and displays in teaching are not a new concepts, in 1973 Horn described that students were "perpetually confronted, enticed, entertained and even overwhelmed by the dynamic imagery of television, movies, and an endless stream of other picture-orientated media" (pp. 18–19); which now with the use of the internet and social media, the volume of visual communications has only grown.

This highlights the importance of being able to create visual displays that can stimulate curiosity and interest amongst staff and students around the SDGs, whilst also motivating and encouraging them to make a positive change towards the underlying SDG targets. Horn further highlights that the most effective and important part of visual communication is that it *commands attention,* reaching out to the intended audience, through applications of colour, variation (which the SDGs already embrace), texture and frequent change, so that it does not simply blend into the background to be forgotten. Currently most research into the behavioural effect of visual communication is focused on advertising and political campaigns, as highlighted by Fahmy et al. (2014), and show that images are powerful in attracting viewers' attention and retention. The power of visual communication in teaching may be underutilised and could be a useful tool to influence student's behaviour patterns towards sustainability.

This chapter aims to inform engagement activities in a variety of different educational and campaign settings to embed the SDGs using mixed approaches.

It will show the initiatives already carried out across NTU in the curriculum to encourage engagement with the SDGs. Followed by collating some of the leading research on communicating sustainability and how this can be translated into an effective SDG communication campaign, emphasising the importance of message framing in communication activities, the inclusion of students in the development phases and being aware of the potential barriers. The final part will provide case studies on the three visual displays that took place across NTU during the academic year 2017–18, sharing best practices and recommendations.

2 Commitment to the SDGs at Nottingham Trent University

Located in the East Midlands of the United Kingdom, Nottingham Trent University (NTU) encompasses approximately 2820 staff and 30,000 students enrolled on around 640 taught programmes. The university has a strong reputation of embedding themes of sustainable development in both curriculum and the everyday activities, supported by its accolades and accreditations. NTU has remained in the top ten of the People and Planet University League, which ranks all universities in the UK since 2009, and it was also the first university in the UK to achieve Gold in the 'Learning in Future Environment' (LiFE) accreditation in 2015. It has also been awarded a number of Green Gown Awards, presented by the Environmental Association of Universities and Colleges (EAUC), as well as the Responsible Futures accreditation from the National Union of Students (NUS) in the UK.

Since the launch of the SDGs in 2015, NTU has chosen to adopt the United Nations' Sustainable Development Goals (SDGs), both as a joint definition of the sustainable development concept and as a framework for all sustainability work undertaken at the university (Erlandsson et al. 2017), with Vice-Chancellor Edward Peck signing the SDG Accord in 2017 (SDG Accord 2017) to further establish NTU's commitment to the global goals. This commitment can also be seen in the *Curriculum Refresh* (Simmons et al. 2016), a university-wide course review process, where sustainability and the SDGs have received a key role in refreshing the taught curriculum to be in line with the Strategic Plan, *Creating the University of the Future* (Nottingham Trent University 2015). As programmes go through this process, they are encouraged to embed at least one of the SDGs and explore ways of collaborating with other subject areas to contribute towards the realization of the global goals. To further establish the connection between the SDGs and programmes, each module leader has the option to embed the goal(s) most relevant to their module in their online learning room and other module materials (see Image 1). This will create a coherent message around the global goals and give students opportunities to explore their own connections to the SDGs.

In addition, the SDGs play an important role in a wide range of sustainability-related projects across the university. The *Education for Sustainable Development: Future Thinking Learning Room* is an online resource bank containing sustainability-related resources which have been mapped against the SDGs. The learning room also collates a range of community and estate case studies, showcasing the differing projects across the university estates with local community connections related to achieving the SDGs (Willats et al. 2017). The global goals are also the focus of the Sustainability in Practice Certificate, an optional online module exploring sustainability issues that is available for all students and staff at NTU (Molthan-Hill et al. 2015).

The NTU Green Academy Team, first initiated as part of the Higher Education Academy (HEA) Green Academy Change Programme (Puntha et al. 2015), are

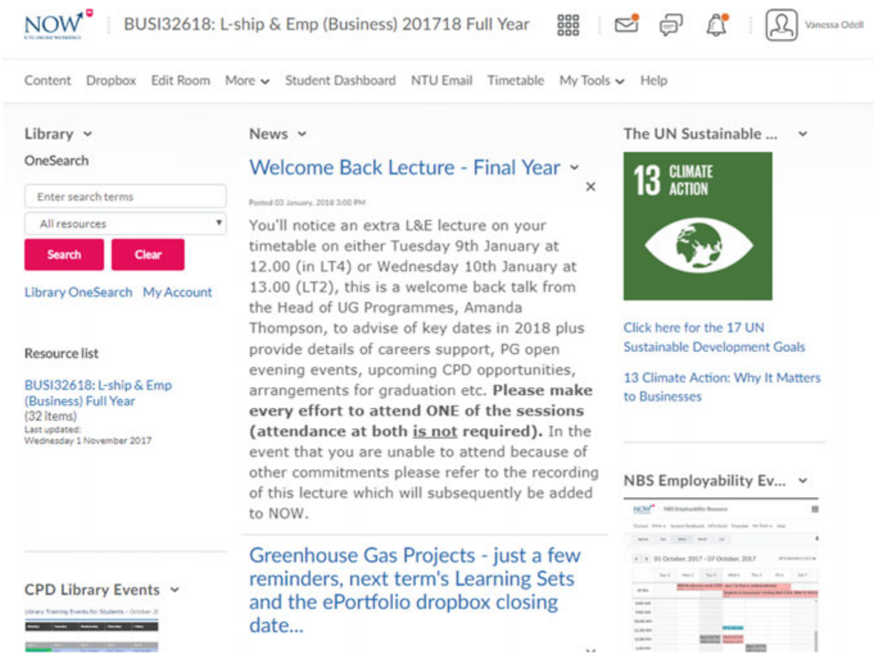

Image 1 Example of SDG 13 in online learning room

responsible for providing support to academics to embed sustainable development initiatives throughout the formal and informal curriculum at the university.

3 Communicating the SDGs

Expanding on the commitment of NTU to support and embed the global goals through top down curriculum-based initiatives, a more comprehensive approach was needed to ensure the SDGs are fully embedded with the inclusion of students from the bottom up. Regardless of the great progress at NTU to embed the SDGs during Curriculum Refresh, it is ultimately the individual programme leaders who will ensure that their students are gaining knowledge on how to act on the global goals and although some academic staff are excelling in this process others are yet to follow. Therefore, to ensure all our students leave with the knowledge of the global goals, teaching and learning must also be taken out of the classroom. As advocated by the future fit framework for ESD (Sterling 2012), sustainability is flourishing where it has been embedded into the curriculum, including curriculum strategies at extra-curricular events. The aim of this project is to utilise different methods of embedding the SDGs and raise awareness of them at university events throughout the academic year.

During Global Week, a festival that celebrates the multinational community of the four NTU campuses, the Green Academy carried out 127 mixed methods questionnaires with students from a variety of different disciplines across each of the campuses. The aim of this questionnaire was to gauge student's current knowledge of the SDGs, showing that 43% of NTU students know about the global goals. Demonstrating that the Curriculum Refresh process has started to have an impact, with 41% of these students seeing the SDGs directly embedded into their courses. The results also revealed other awareness activities where students have seen the global goals, with 47% saying that they have seen them at NTU events, highlighting the importance of extra-curricular activities. Students had also seen the SDGs on NTU social media, during the NTU's Sustainability in Practice online course and externally to NTU. However, these questionnaires also revealed that there is still a way to go in raising awareness of the SDGs at NTU with 57% of students having never heard about them. The results further highlight the importance of using a mixed methods approach to raise awareness of the SDGs.

It is no surprise that our results show that diverse methods are the best way to teach the global goals, in relation to Education for Sustainability, Sterling (2012, p.37) emphasises that '*learning methods and approaches need to be more open-ended, participative, diverse and interactive than is often the case in academic teaching*'. The development of the visual displays project not only aims to further raise awareness of the SDGs at NTU but also looks at how to encourage, motivate, and facilitate students and staff behaviour to think about how they can contribute to meeting the SDGs underlying targets. Engaging both staff and students to participate in the development phases of the visual displays projects, as co-partners, in creating the sustainable *University of the Future* (Nottingham Trent University 2015), whilst also recognising the importance of making them interactive as possible.

4 Supporting Research for Visual Communication of SDGs

During the development of the visual displays project, the engagement activities were based on current research to build a strategy of communication. By raising awareness and working towards the global goals, it is hoped that students and staff will be more engaged and active citizens in contributing to sustainable development. Godemann and Michelsen (2011) posit that it is not enough to raise awareness of the sustainability concept, but people also need to be mobilised through knowledge linked with a direct experience that has meaning and encourages an emotional response, which can also have a practical value; for which the SDGs mostly fit the description and give goals that staff and students can work towards.

4.1 Framing the Message

The contested definition of sustainability is problematic when trying to embed sustainability across the university, as each discipline conceptualises it differently. Shome and Marx (2009) provides the benefits of message framing through organising an issue around a central context, whilst linking this to immediate action with the use of 'shortcuts' and symbols, as the SDGs have done for sustainability. The SDGs framework is the perfect opportunity to bring a common understanding of sustainability across the disciplines at the university illustrated previously by Molthan-Hill et al. (2015).

This central framework for sustainability is helpful to encourage positive behaviour change across the institution. Not only can they explore sustainability in many different dimensions by focusing on a few of the 17 individual goals or underlying 169 targets, they can be used to encourage individual action and promoting self-efficacy. The challenge is to translate these targets into action, framing a message that is not just facts and data but to also tell a story that ignites our imagination for what can be done. It should be noted that with the 17 goals and 169 underlying targets, the SDGs are complex in what they are trying to achieve, but also complex to understand when first seeing them. Therefore communicating a few of them at a single time so that they are not overwhelming, and in a way that draws attention is a central feature of the visual displays project.

Transforming the global goals into action depends on how individuals respond to information given to them during the visual displays. Graham and Abrahamse (2017) state the importance of peoples pre-existing values, and tapping into these to enhance the effectiveness of communication campaigns. Their study on people's attitudes and values towards eating meat, framed messaging around two values sets, the extrinsic self-enhancing value set which looks at how the individual will benefit, compared to the intrinsic self-transcendence value set that may be influenced by more collective framed messaging. Therefore, framing messaging to your intended audience is vitally important and tailoring these messages to suit their particular value set will be the best approach to influence students and staff attitudes and behaviour. Our main target audience, the students, are at a point in their lives where they have chosen to come to university to enhance career progression and enjoy themselves, therefore individually framed messaging may be more appropriate. However, Shome and Marx (2009) state the importance of framing from multiple perspectives therefore messages that show our collective impacts were also used during the display. Insights from psychological science (van der Linden et al. 2015) advocate that people evaluate losses and gains differently, and by focusing on positive 'gains' from actions that individual staff and students can take this will increase the support of working towards the SDGs during the visual displays.

4.2 Engaging Students in Developing SDG Visual Displays

The inclusion of students working with the Green Academy to produce an effective strategy of communication via visual displays, is an important part of education for sustainable development (ESD) projects.

> The goal of an education for sustainable development (ESD) is to help create the conditions for self-determined and autonomous action and not just to train changes in behaviour. ESD aims at developing and enhancing the creative potential in the individuals, his competencies in communication and cooperative work as well as problem-solving and taking action. Godemann and Michelsen (2011, p. 10)

In order to nurture the creative potential of students, workshops were developed for two of the three final visual displays as shown in the case studies, including problem solving activities and encouragement on how to call for action on the SDG targets. By including students this way, it can subsequently transpire to unexpected rewards as shown in the final cast study. Horn (1973) also highlights the importance of involving students in the design and construction of projects so that it can help draw attention to the issues the SDGs are trying to solve, and more importantly they can signal to others how they should act to work towards them.

van der Linden et al. (2015) developed five ‘best practices’ to improve public policy making on climate change:

> (a) emphasize climate change as a present, local, and personal risk; (b) facilitate more affective and experiential engagement; (c) leverage relevant social group norms; (d) frame policy solutions in terms of what can be gained from immediate action; and (e) appeal to intrinsically valued long-term environmental goals and outcomes. (van der Linden et al. 2015, p. 758)

Adapting the five ‘best practices’ in the context of communicating the SDGs, the Green Academy developed workshops both followed a similar structure to help students address behaviour in sustainability. First, the workshops emphasised an issue of a particular goal that the visual displays need addressing, during the workshops the Green Academy used experiential engagement activities where the students evaluated behaviour change models, discussing how to lever social group norms, and submitting ideas that showed the benefits of immediate action appealing to the long-term goals of the SDGs. This allowed the students to reflect critically on not just their own actions, but everyone’s actions collectively, whilst also allowing them to influence sustainability change within the university in a positive way (Godemann and Michelsen 2011) through the creation of a visual display.

4.3 Barriers to Communicating the SDGs

Problems that relate to the economy, environment, social welfare and health (Newman-Storen 2014) such as loss of biodiversity loss (Sharman and Mlambo 2012), and climate change (Head 2008; Sun and Yang 2016) are increasingly being referred to as 'wicked problems'. This is attributed, to their complex nature with complex solutions that are not immediately available, nor solvable (Rittel and Webber 1973). The SDGs provide the opportunity to collate these 'wicked problems' and outline the specific goals to end them. However, due to the complexity of the issues covered there is a danger to overwhelm and in fact disengage people. According to Shome and Marx (2009) people have a limited capacity to worry, thus only using a few of the global goals during the visual displays is significant.

Using visual aids prompts engagement from students and staff with the SDGs in a positive manner for them to work towards the targets, without exasperating public disengagement with sustainability issues. Chapman et al. (2016) discusses how visual mediums may be a potentially powerful way to connect people with issues of climate change [and sustainability issues] by contextualising less familiar concepts through images. Creative visualisation has been argued to be helpful with communicating sustainability issues (Adomßent and Godemann 2011; Manzo 2010), however, using frightening, sense of fatalism images should be avoided, as they may draw attention to the issue, but they are likely to disengage the public further and disempower them. This view is also supported by O'Neill and Nicolson-Cole (2009) who recommend that using personal changes that the individual can make will likely increase self-efficacy. Communication for social change must consist of efforts to increase student and staff motivation and help lower the barriers (Moser and Dilling 2007) to the realisation of the SDG targets.

Djordjevic and Cotton (2011) summarise some of the communication barriers that the visual displays have sought to overcome. Complex messaging that is not contextualised for the intended audience can be prevented through including students during the development phases. The problem of shared understanding about sustainability is overcome using the SDGs framework. Ensuring that the message sender does not lack authority, as Nisbet and Kotcher (2009) highlight, these 'opinion leaders' are important to accelerating behaviour change, the person communicating the message not only needs to have knowledge of the issues to tailor the information for individuals they also need to have charisma. Working in collaboration with other teams such as NTUs Global Team and Sustainable Development team (estates focused) help combine efforts to prevent too much noise in the channel which causes confusion and feelings of being overwhelmed with messaging. Finally, the last barrier mentioned is focusing too much on electronic communication rather than in person, highlighting the importance of being at different events across the institution.

The supporting research and behaviour change models used for the SDG visual displays are not intended to be exhaustive. As Ballantyne's (2016) research highlights climate change communication is suffering from 'conceptual confusion' where communication is far more complicated than the theories advocate. For the intended purpose of creating awareness campaigns of the SDGs through the visual displays project, mixed approaches are applied to frame messaging with students and staff values in mind and develop best practices. Each visual display will provoke a recognition of large-scale problems, contextualising the less familiar (Chapman et al. 2016) and highlight the tangible benefits to try and leverage social group norms (van der Linden et al. 2015).

5 Case Studies of Visually Displaying the SDGs

This chapter will showcase case studies describing visual displays that took place over the academic year 2017–2018 during three separate themed weeks at NTU—Green Week, Global Week, and Fashion Revolution Week. Compared to other methodologies commonly used, the case study methodology is often said to be unable to provide general conclusions and repeatable outcomes. Instead, this method allows to get an insight into real-life, practical examples (Yin 2009) and get an understanding of the outcomes of contemporary projects. Hence, the aim of this chapter is to provide tested models of good practice to inspire others to develop their own practical ideas that can be implemented in other educational settings.

5.1 Case Study 1: Food Impacts and Working Towards SDG 12 Responsible Consumption and Production and SDG 13 Climate Action

Each year NTUs Sustainable Development Team and Green Academy Team run a series of events aiming to raise sustainability awareness across the entire university during Green Week. This year's chosen theme was food waste, directly relating to SDG 12 target 3: 'By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses' (United Nations Sustainable Development 2018). During Green Week, the two teams collaborate to make as much noise as possible through activities including: the food impacts SDG visual display visiting all NTU campuses, a food waste photography competition open to everyone, all NTU Dine outlets offered a low carbon menu, a 'Love Food Hate Waste' workshop ran for students at Brackenhurst campus after food waste caddies had been introduced to halls, a session in the allotment at Clifton Campus to learn how to compost food waste, a food themed 'Sustainability in Practice Challenge' day (Dharmasamita et al. 2016), several film screenings of the BBC Simon Amstell mockumentary 'Carnage' with a discussion on the impact of our diets, and three contributions to our online NTU SDG blog by an associate lecturer in the Green Academy writing about the expectations, half way point, and outcomes of COP23 which was also taking place during this week.

The first SDG visual display was kept relatively small, to discover what works and develop best practices within the Green Academy. Individually framed messaging was the central theme chosen for this display due to the Graham and Abrahamse (2017) research on the values and attitudes of individuals towards meat, showing that both value sets, self-transcendence and self-enhancement, both responded better. However, to ensure there was a diversity in the messaging to reach as many staff and students possible, the collective impacts were also shown as part of a competition where students and staff guessed the amount of beef burgers thrown away each year in the UK.

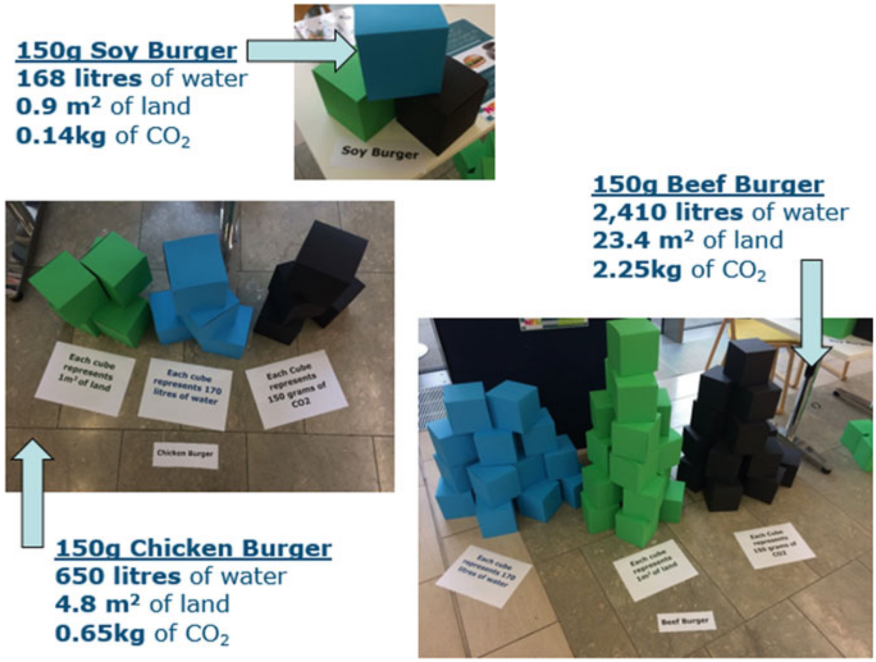

Image 2 Food impacts visual display on SDG 12 and SDG 13

The focus of the visual display was to encourage students and staff to make sustainable food choices by raising awareness of the impact of three different types of burgers: beef, chicken, and soy, showing the water and land resource impacts of each individual burger, along with the associated carbon emissions (Image 2), which Graham and Abrahmse (2017) advocate is necessary to move to a low carbon society.

This display also linked with three of the SDG targets: 12.2 'Achieve the sustainable management and efficient use of natural resources', 12.8 'Ensure that people everywhere have the relevant information for sustainable development and lifestyles in harmony with nature', and 13.3 'Improve education, awareness-raising, and capacity on climate change management' (United Nations Sustainable Development 2018) which were shown on large posters on display boards. The boxes for the display were sourced from a sustainable supplier and are made from recycled paper.

By looking at the impact of different types of burgers, the display aimed to show an unfamiliar problem and contextualise it into something visible, to encourage individuals to eat less beef to reduce environmental impacts, but also to demonstrate the absurdity of the amount of beef that collectively gets wasted each year in the UK equivalent to 300,000 beef burgers (Smithers 2016). The display drew attention, with most common response being disbelief at the resource cost of a single beef burger.

5.2 *Case Study 2: Ocean Plastic and Working Towards SDG 14 Life Below Water*

Building on the learning of the Green Week visual display, students were involved in every part of the process for the next visual display, including developing the concepts for the ocean plastic visual display as well as creating it. To get students involved the Green Academy advertised two ocean plastic visual display workshops via NTU event pages, NTU social media, and through the support of academics sharing the advert with their students. Incentives were used to encourage student engagement with a competition for the best idea for the visual display, including £150 budget for the winning project and a £50 reward voucher once the project was complete.

The two workshops were fully subscribed with ten students in each, they took place over two consecutive days, at different times, to support student attendance. The purpose of the workshops was to give students a clear background and understanding to develop a visual display idea, that then students can submit three days after the workshops. A short 10-min presentation introduced students to the outline of the workshop, the SDGs, and the issue of ocean plastic. The first activity was an icebreaker where students were put into three groups and were asked to share with each other their names, what course they were on and why they came to the workshop along with choosing a silly team name, helping them relax and realise why they were taking part. To come up with solutions, students were first asked to understand the problem in more detail and were shown the ISM Model (see Fig. 1).

Using the ISM model allowed students to see behaviour change outside of the individual context and understand the problem in detail. Not only could they see the individual factors that affect people's choices and behaviours, it also showed them the factors that exist beyond them in the social realm and the material factors which shape people's behaviours. Once introduced to this model, students worked in their groups to evaluate the problems surrounding ocean plastic which were then shared and discussed with everyone via a fishbone diagram (see Image 3).

After exploring the problem, the students then reflected on which behaviours they could focus on for the display. The final activity was showing students successful campaigns and followed on by a discussion of which ones they liked and why. To end the session students were then given a project idea development sheet with the criteria for which they would be scored, firstly they had to include SDG 14 target 1 'By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution' (United Nations Sustainable Development 2018), raise awareness of plastic pollution, and think about the logistics of how easily it can be moved around the campuses and be safe.

All students that attended the workshop handed a completed project proposal form, which NTU's Green Academy scored. Two projects ideas stood out from the rest, the first was the SDG 14 logo made from 446 bottle tops (see Image 4) to show approximately how many plastic bottles that are thrown away every second in the

Fig. 1 ISM model, The Scottish Government, 2017

UK, developed by a student in the Animal, Rural, and Environmental Science School at NTU.

The second idea was created by an NTU Art and Design student, Eleanor Sexton, whose idea was fun, playful, and commanded attention. Not only did she spend time creating the display, she also built social media presence and included this project in her final dissertation portfolio. Using the arts to convey our message as useful in making sustainability information more interesting to the students and staff at NTU and present it in a way that is easy to remember (Curtis 2011).

The Sustainable Hippy visual display (Image 5) aimed to incorporate SDG 14 Life below Water, whilst still being visually and mentally stimulating to the millennial demographic. As part of the primary research for her final year report focusing on packaging, the findings suggested that recyclability is often dull using grey visualisation. The Sustainable Hippy was created to push the boundaries of this perception, having an awareness of cultural and societal macro and micro trends. This concept primarily dominates on the realisation of natural disaster, through WGSN's Psychotropic theme (2018), which explores an idealised futuristic vision of nature. To connect to a range of demographics (primarily Millennials and Generation Z), the display aimed to inform and educate in a fun and light-hearted way, yet communicate

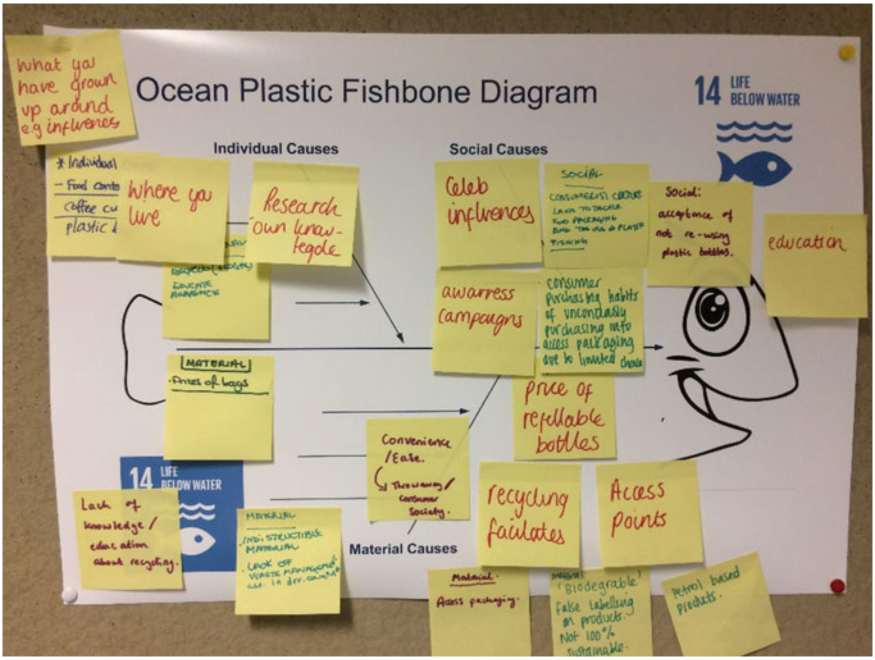

Image 3 Ocean plastic workshop ISM fishbone diagram activity

Image 4 SDG 14 life below water plastic bottle top visual display

Image 5 The sustainable hippy visual display

the issues around ocean plastics and hold a high-level of importance and meaning, whilst showing what the present and future holds without action.

The Sustainable Hippy is made from recycled material from a local scrap store in Nottingham, clashing multi-mediums to represent how marine life is interrupted by our behaviour. This is visually represented within the concept through the plastic-filled stomach and the character's light-hearted yet unhappy tone-of-voice. Research from Hamid et al. (2017) points out the importance of utilising social media as the most effective way to communicate sustainability issues. The Sustainable Hippy was promoted through the social media platform, Instagram (@thesustainablehippy), which taps into the ISM model used during the workshop hoping to encourage behaviour change through social influences.

To create a successful concept, the students chosen communication strategy was to link the display to the past, proposing the audience are more likely to feel an emotional response when exposed to vivid imagery that connects to personal experience using both processed systems of the human brain (Shome and Marx 2009). For this visual display, the goal was to channel the 1960/70s hippy movement, an aesthetic that is humorous and adds an authentic personal touch, which has proven during Global Week to be a great tool to capture the audience. Therefore, The Sustainable Hippy portrays a fun-loving, slightly unusual but real personality that is diverse in identity and attracts the public through happy energy steering clear from framing the message with fear. This ultimately invites the interest of the audience, who want to know the story, and purpose behind the visual display.

Both displays were shown during Global Week's activities on each of the NTU campuses. Using an art display positively assisted public engagement during the week where 183 students pledged to reduce their own plastic usage and stop using disposable plastic bottles. Along with 127 students filling in a questionnaire looking at their engagement with the SDGs during their time at NTU and leaving feedback on which part of the display they thought to be the most impactful. The SDG 14 logo display and The Sustainable Hippy both took precedence over the information posters, fact sheets and social media. The Sustainable Hippy gained 87 followers and now regularly posts about to reduce our own plastic footprint.

5.3 Case Study 3: Fast Fashion and Working Towards SDG 12 Responsible Consumption and Production and SDG 10 Reduced Inequalities

The final display of the academic year took place during the international campaign Fashion Revolution Week (2018). By running alongside and supporting the larger campaign the Green Academy were able to make use of their materials and save time. Students again developed the visual display first through an interactive workshop looking at a behaviour change model, followed by students submitting their ideas. The promotion of the workshop followed the same method as the Ocean Plastic Workshop promotion including the £150 budget for the successful project, however, this time the £50 reward voucher was removed to see if students still showed an interest without a financial incentive which seemed to work. The workshop ran once with 15 students due to their availability, with the majority opting for one particular date.

The purpose of the workshop was to introduce the students, if they were not already familiar, with the Fashion Revolution Campaign and the SDGs. The first activity was the same as the previous workshop including a short introduction to why they had come. In order to help students develop their concepts for the display they were introduced to the Unilever Five Levers of Change Behaviour Change Model (2017). During this activity students were encouraged to look at the individual impact of Fast Fashion including both the social & economic wellbeing and environmental impacts whilst applying and evaluating Unilever's Five Levers of Change (2017) model.

After going through the five levers in their group's students then used sticky notes to put their ideas on a larger collective poster of the model, followed by a group discussion (see Image 6).

After looking at the levers, students discussed how fashion sustainability could be more easily understood through lectures and events, the difficulty of trusting brands and how hard ethical information is to find. They then evaluated the activities that could reduce this impact such as upcycling, recycling, and swapping clothing events.

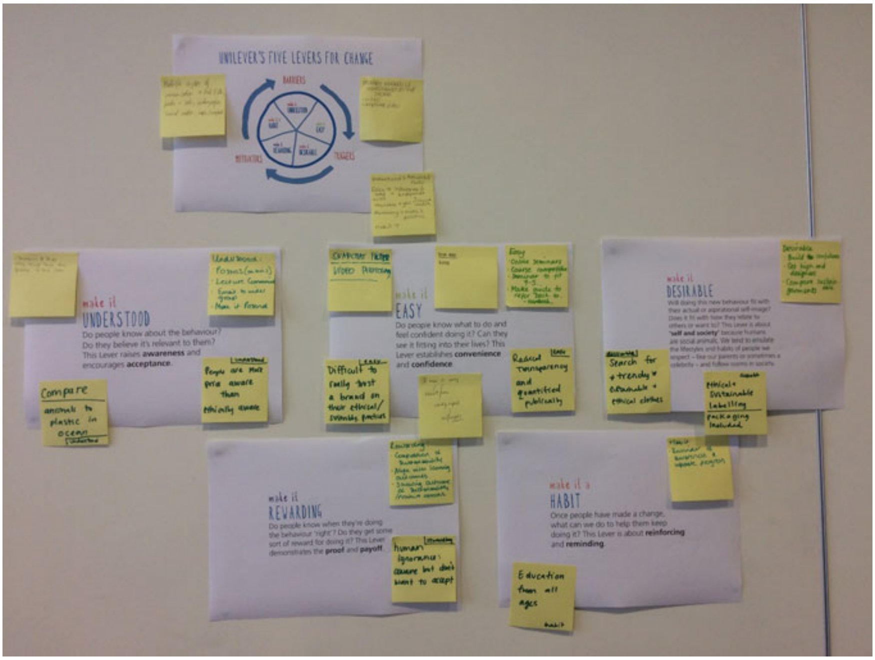

Image 6 Fashion revolution workshop Unilever's five levers activity

Students during this workshop were really engaged and set up a working group via social media so that they could continue to communicate about Fashion Revolution Week. One surprising outcome of the workshop was that the fashion students who had taken part had started a petition to embed the sustainability in practice certificate into their programme of study, gathering 37 student signatures. The fashion programme leader is now in contact with the Green Academy looking at embedding this for the next academic year.

The final visual display idea was developed by a student in the Nottingham Business School, their idea was to raise awareness of the SDGs using labels to show which targets relate to the fashion industry and how they are combating different global issues (see Image 7). For example, showing the estimated number of children working in garment production, and then connecting it to the solution SDG 8 target 7 'Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms' (United Nations Sustainable Development 2018). The SDG targets used in the visual display 1.1, 1.2, 5.1, 6.3, 6.6, 10.4 and 12.5 the display also raised awareness of what direct actions people could take such as choosing sustainable fashion labels, for example EU Ecolabel, Fairtrade, Better Cotton

Image 7 Fashion revolution week SDG visual display

initiative, Fair Wear Foundations. The parts for the visual display, the clothing and mannequins were borrowed from the Art School.

During the week students took photographs of themselves with the 'who made my clothes' sign which was then used on our Instagram, @sustainabilitydiaries to tag the brands they were wearing as part of the larger international campaign to ask for transparency in supply chains across the fashion industry. The workshop students also ran a clothing swap event alongside the visual display stall.

6 Conclusions and Recommendations

Taking ESD out of the classroom is a dynamic, interactive, and delightful way to teach sustainability using the SDG framework during extra-curricular events. Supporting research has highlighted that engagement should not just focus on the giving of knowledge but should include a personal, emotional connection, whilst contextualising unfamiliar problems in a way that is easy to understand. Visual displays are useful in this context to promote efficacy, empowering individuals to be part of the solution and change their behaviour to contribute to the realisation of the SDG targets.

Message framing is difficult given the complexities across communication theory. However, drawing on the theories has allowed for some best practices for creating visual display to be developed to raise awareness of the SDGs. The most important learning from our displays is the inclusion of students, using their creative potential for the development of the displays allowed insight to the targeted audience, making the behaviour change campaign more effective. Collaboration with other teams is another significant learning as this allows the campaign to get more of an outreach by jumping off already established groups and events to gain maximum impact, such teams at NTU included: Sustainable Development Team, Global Team, and the Green Art Students Group. Face to face contact has been highlighted as crucial for communication campaigns, having an enthusiastic opinion leader to develop and exhibit displays can help make the campaign impactful.

The content of the visual display has been most impactful when the message was short, clear and consistent, whilst avoiding overwhelming the audience with too much information and not using fear framing. Another observation is that using campaign ideas based around what is topical in media such as Ocean Plastic helps engagement along with using artistic messaging. It is hoped that the best practice developed during the three visual displays will inform engagement activities in other educational settings using mixed approaches to embed the SDGs.

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Sustainable Development Goals and Current Sustainability Actions at Politecnico di Torino

Giulia Sonetti and Patrizia Lombardi

Abstract Adopted by the UN General Assembly in 2015, the agenda of the 17 Sustainable Development Goals (SDGs) represents a new coherent way of thinking about how issues as diverse as poverty, education and climate change fit together; it embeds economic, social and environmental targets in an holistic way. Implicit in such SDG logic is that each goal relies on another, although there are no clear ways to measure this intersection. International negotiations are obviously one trial table of these trade-offs. Universities, with their broad responsibility in the creation and dissemination of knowledge and their exceptional position within society, have a crucial role to play in the achievement of the SDGs and in understanding the complexity underling them, since they can help to demonstrate the university impact on society, shape an SDG-related education, build new partnerships, access new funding streams, and redefine the strategic plan of a university. This paper explores the way Politecnico di Torino maps its actions through the lens of a mission-based university, where SDGs can restructure and update the whole knowledge transfer approach to students and among staff. However, this transition is still difficult since departments and administrative unites operate in silos and the leader's agenda does not allow a real flexible and adaptable model to feed in. Researchers and administrators also lack tools to identify which interactions are the most important to tackle, and evidence to show how particular interventions and policies help or hinder progress towards the goals. Given the size of the task of achieving the SDGs, this mapping exercise provides interesting stimula for the academic sector to accelerate insights on the SDGs complementarity and prioritization.

Keywords SDGs · University · Collaboration · Strategic plan · Sustainability education

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1 Introduction

Today's global society faces pressing, complex challenges across many domains —including health, environment, and social justice (EC 2010; Leach et al. 2010; Wolch et al. 2014). Science (including social sciences), technology, the arts, and humanities have critical roles to play in addressing these challenges and building a positive and wealthy future. Universities are nuclei for breaking through, structuring new awareness, and varying our vision of the world (Ferrer-Balas et al. 2009; Lozano et al. 2015; Segalas et al. 2010). The role of universities in education is of public value; also, universities are often promoters of new businesses led by new values, in being spots for nurturing the ground science that leads to new products, or in producing evidence on which policy decisions should be made (Corbett 2005; Disterheft et al. 2014). By coming together as universities, collaborating with partners, and aiming for ambitious goals to address problems that might seem unsolvable, universities can show commitment to their communities and become inspirations for change (Ferrer-Balas et al. 2010; Lozano et al. 2014; Sonetti et al. 2016).

Mission-oriented policies can be defined as systemic public policies that relies on frontier knowledge to reach specific results (Mazzucato and Penna 2015). Missions provide a visible goal, a key, and a key to address the challenges that people face in their daily lives, whether that concerns air pollution, health and wellbeing in urban context of for the ageing societies, equal access to education and technologies enabling public services and fair trade (Edquist and Zabala-Iturriagagoitia 2012). To engage research and innovation in meeting such challenges, a clear direction must be given, while also enabling bottom-up solutions. The debate involves a wide array of stakeholders, and it is led by wider and over-national aims. The 17 Sustainable Development Goals (SDGs), articulated in 169 Targets to be reached by 2030, were born to respond to this need (Flückiger and Seth 2016).

The SDGs constitute a big occasion for University to restructure its strategy and bring up-to-date the education system to respond to the current societal challenges (Leal Filho et al. 2018). Given the size of the task and the critical role universities have in supporting, researching and delivering on them, there is an urgent need for the educational sector to accelerate insights on the SDGs complementarity and prioritization (Hartz-Karp and Marinova 2017). However, this transition toward a mission-based university is still difficult, since departments and administrative unites operate in silos and the leader's agenda does not allow a real flexible and adaptable model to feed in (Klein 2015; König et al. 2013; Tejedor et al. 2018). Researchers and administrators also lack tools to identify which interactions are the most important to tackle, and evidence to show how particular interventions and policies help or hinder progress towards the goals (Ferrer-Balas et al. 2010; Meadowcroft 2009; Parris and Kates 2003). Indeed, "missional motivation" has been regarded as one of the factors triggering the co-creation of sustainability, forming multi-actor partnerships and implementing solutions for localised issues (Yarime et al. 2012).

This contribution highlights the match between the current sustainability strategy at the Politecnico di Torino (PoliTO) and the SDGs, introducing the national context in which Italian higher education institutions are gathering toward the same sustainability objectives, mapping the SDGs and the PoliTO's activities in the six work areas of the Green Team (Energy and buildings, Mobility and transport, Urban outreach, Food, water and waste, Green procurement and Communication). The last part of this text draws the conclusions for PoliTO's weaknesses and opportunities, and potentially for all the other universities already *en marche* towards a sustainable path.

2 SDGs and the Italian Situation

On 25 September 2015, the United Nations approved the Global Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs in the English acronym), articulated in 169 Targets to be reached by 2030 (United Nations, Population Division 2015). It is an historical event, because eventually a clear judgment has been expressed regarding the unsustainability of the current development model, not only on the environmental level, but also on the economic and social ones (Kates et al. 2005; Kates et al. 2001). In this way, and this is the highly innovative character of the Agenda, the idea that sustainability is only an environmental issue and an integrated view of the different dimensions of development is definitively overcome (Giovannini 2018). This primary goal of intergenerational equity extends the reference horizon of choices and provides foresight for government action (Griggs et al. 2013). This is realistically possible where the value, the communicative and inspiring power of the SDGs becomes part of daily life, impacting concretely on the behavior of individuals and organizations (Colglazier 2015). Implicit in the SDG logic is that the goals depend on each other, even if there is still great uncertainty on how it happens.

The challenge for complex, multi-center and multi-stakeholder organizations, such as universities, is to seize the opportunities of the Agenda 2030 (Hajer et al. 2015; Martin and James 2012; Sachs 2012). Operationally, they should be able to promote new institutional governance mechanisms, coherently orienting internal decision-making processes, allocating resources, redesigning both the organization's mission and the system of incentives for teaching and research (Cortese 2003; Di Nauta et al. 2015; Waters 2013). And this is not easy.

The initial move of Italian university toward the SDG concepts was the launch of the Italian Alliance for Sustainable Development (ASviS) was established on February 3rd, 2016, upon the initiative of the Unipolis Foundation and the University of Rome "Tor Vergata" (http://asvis.it/).

This is consistent with the first principle of the Agenda 2030, that requires the universality of the commitment to change, not only in the sense that all countries must play their part, but that all the components of a country must be involved, not only public but also private, civil society and so on. From this comes the second principle, that is the participation (Ferrer-Balas et al. 2009; Hopwood et al. 2005; Sachs 2012). The aim of ASviS is indeed to raise the awareness of the Italian society, economic stakeholders and institutions about the importance of the 2030 Agenda for Sustainable Development, and to mobilize them in order to pursue the Sustainable Development Goals (SDGs) (Giovannini 2018). This alliance already brings together over 180 of the most important civil society institutions and networks at national level, such as: associations representing social partners (businesses, trade unions and third sector associations); networks of civil society associations pursuing specific goals (health, education, employment, environment quality, gender equality, etc.); associations of local public administrations; public and private universities and research centres; associations of stakeholders working in the fields of culture and information; foundations and networks of foundations; Italian organizations that are members of international networks dealing with the SDGs.

The 2030 Agenda was the result of a two-year negotiation between governments and therefore is the result of a mediation, not all-encompassing but well structured, that includes and shows the connections, also operational, among the different subjects. An example: the Third Sector Forum asked its associates to reclassify the activities carried out according to the targets of the Agenda; the request that could have been understood as a bureaucratic burden, but instead it was accepted with a great participation, with a sense discovery, as a break with the routine and a way to deal with one's own historical legacy and with other subjects.

Moreover, in AsviS there are subjects that historically have had different positions on many issues (for instance, the environmental ONGs, or the production actors such as "Confindustria", "Confcommercio", with the trade unions CGIL, CISL and UIL). In these two years, the ASviS network has not been an intrusive component, but it has represented an added value. For example, the report produced each year with the contribution of 300 experts is sent to all associations before its publication, being a collective product that welcomes different points of view.

Working together on the Agenda 2030 targets represented a model of integration between very different realities that have discovered the value of working together, inspiring also the Italian Sustainable University Network (RUS), born with the aim of promoting the SDGs, spreading the culture and good practices of sustainability and strengthening the value of the Italian experience at an international level. The RUS, co-founded by Politecnico di Torino (PoliTO), in July 2015 with other Italian Universities, represents the first experience of coordination and sharing for all higher education institution involved in the issues of environmental sustainability and social responsibility. In this perspective, PoliTO, also partner of ASviS, adopted the United Nations Agenda 2030 as an innovative guideline for an integrated approach to strategic planning and social reporting, in which to give expression of the effects of government action in terms of economic growth, social inclusion and environmental protection. The multi-year experience acquired by PoliTO through a process of reporting that combines the economic dimension with the social and environmental, has had as a natural outlet the questioning of the status quo regarding the university missions of teaching, researching and outreaching, to contribute to the Agenda 2030 (Green 2013; Lauder et al. 2015; Lozano et al. 2014).

3 The SDGs Mapping Exercise at Politecnico di Torino

Energy efficiency strategies and pro-environmental actions have been in place by PoliTO for almost 20 years, as well as concrete choices of emissions avoided thanks to the renovation and reuse of historic buildings, the continuous promotion of leadership and innovation in sustainable technologies, seminars for students and staff aimed at enhancing a wiser use of our resources. Nevertheless, it has been only in 2015 that the "PoliTO Sustainable Path" was promoted by the vice-rector to logistics and infrastructures at the institutional level. A dedicated internal team, the "Green Team" (Fig. 1), was created to support the best international universities in recognizing our role as drivers of change toward a low-carbon society.

This team is intended to lead the PoliTO towards the university sustainability mission, as stated in the Horizon 2020 strategic plan: a comprehensive integration of sustainability into the university research, teaching, outreach and operations that prepares students, faculty and staff to be sustainability leaders in their professional, personal and civic lives.

The Green Team of Politecnico di Torino is the hub of skills, material and human resources and information related to the objectives of sustainable development translated into the university. It coordinates all activities related to the promotion of sustainability in the University to ensure that the SDGs are integrated into all the activities of the institution (both educational and awareness and dissemination), and to align and optimize the way resources are deployed in national and international projects.

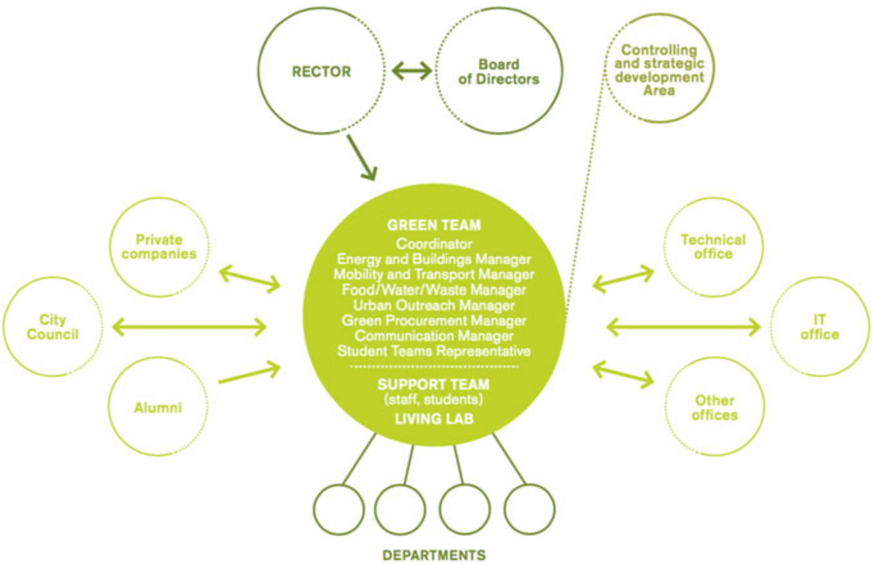

Fig. 1 The Green Team governance model

The Green Team is therefore the unit of connection between the university community and the general management board for ensuring the implementation of the SDGs in different processes transformations already in place. It is organized by vertical lines of action on six themes: Energy and buildings, Mobility and transport, Urban outreach, Food, water and waste, Green procurement and Communication. These vertical actions are then flanked by transversal and multidisciplinary "engagement" actions, coordinated and supported by administrative members, researchers and student representatives attentive to the wider impacts that fall into the "third mission", in the campaigns of inclusion of sustainability in research and teaching, in internal and external dissemination, to the wider community of the city and in the networks of universities with similar goals in Italy and in the world.

The vision of development underlying the new Green Team program document[1] is already offering clear and transparent decision-making criteria for the enhancement of multidisciplinary heritage in the planning of new training initiatives and in the policies for encouraging research on SDGs, but there is still no clear threshold to understand the starting point and the status quo of SDG integration into current and future activities. In order to aligning the Green Team vision on decision-making criteria by the administrative board a sustainable development objectives, PoliTO wanted to start a re-reading of its teaching, research and third mission activities according to the 17 objectives and sub-objectives, proposed in the UN Agenda 2030.

For this reason, the Green Team is conducting a three folded initiative as follows: (i) One is an in-depth analysis to define the criteria for evaluating the correspondence between current activities and SDGs. In collaboration with special projects office and IT departments, an Artificial Intelligence device is being trained to suggest which SDG is most likely related to a research product as found in the last five years in the PoliTO scientific products repository. The papers/book chapters/proceedings mapped via the algorithm have to be validated by the corresponding authors. This is first of all to take ownership of the 17 Sustainable Development Goals of the United Nations, and then to inform the government action of the new rector for a shared vision towards a more sustainable society. (ii) The same mapping detail action has been undertaken at the level of teaching course with reference to the current education portfolio opportunities offered to students. This activity has been just started and will be concluded by end of June. (iii) An initial activity undertaken by the Green Team has been to link existing and forthcoming lines of actions toward a sustainable campus with the 17 SDGs to demonstrate university impact, capture demand for SDG-related education, build new partnerships, access new funding streams, and ri-define the strategic plan of a university that is responsible and globally aware.

Given the amount of publications to be analyzed (over 13,000 for the last 3 years) for the (i) initiative, it has been tried to perform a classification test using a semi-supervised classification tool. This was the "Watson", a question-answering computer system capable of answering questions posed in natural language, developed in IBM's DeepQA project (Ferrucci et al. 2013).

[1] http://www.campus-sostenibile.polito.it/output_and_publications.

Some possible basis of knowledge for teaching the AI system have been defined by the Green Team's dedicated working group. The analyses were conducted separately for each language (English and Italian) and therefore the knowledge bases were always separated into two sets. Three types of tests were done, using three different knowledge bases: the definitions of the SDGs as extracted from the UN official website; 5 publications certainly attributable according to the highest Google Scholar citation index for each SDG; a sample of about 100 PoliTO's publications, manually classified by the Green Team members, expert of each "category" of goals. Preliminary results of the three analyzes show a polarization on three SDGs: 7, 11 and 12. In general, the analysis based on the official UN definitions returns a greater distribution on all the SDGs. A significant difference is in the third type of analysis, which returns 6545 classified publications compared to about 4000 of the other two. It therefore seems to be less resolving than the others. It appears clear that a human control is necessary to cut out the "false friends" retraced in a quick control over few publication, where the word "environment", for instance, was strongly related to the IT semantic realm, rather than to the SDGs "life below water" or "life on land". While the polarization toward SDGs such "affordable and clean energy" or "industry, innovation and infrastructure" is quite predictable in a technical university such as PoliTO, having just engineering and architecture departments, it is essential to carry out a human driven punctual verification of the classification obtained, on a significant sample, that is now undergoing at the time of this writing. Therefore, in the following sub paragraphs, the result of the iii) activity related to current results/targets mapped on SDGs per action lines exercise is presented.

4 Energy and Buildings

Pursuing energy sustainability at Politecnico di Torino means reducing and rationalizing energy use and its environmental impact on campus reality. PoliTO's energy consumption in 2014 accounted for 5064 toe, while in 2015 the total decreased to 4967 toe, 4 987 toe in 2016 and 4398 toe in 2017, decreasing by the 13% in four years.

The carbon foot print is 2217 tons of CO_2, as 100% of electric energy comes from renewable sources. In 2015 we consumed 4.0 koe per cubic metric and 166 koe per student, while in 2016 this last portion decreased to 151 koe per student. While providing the quality/comfort of indoor spaces, plus the security and the affordability of the supply, PoliTO aims to make its building structures more efficient, and to produce and/or to buy energy from renewable sources. Energy sustainability of the University therefore concerns plants, buildings and sources. This dimension, besides all action aimed at saving energy and fostering the widespread use of renewable sources, includes the monitoring of all resources, the real-time control of these flows (with the Living Lab facility) and the adoption of new management methods for energy saving. Therefore, the PoliTO priorities in the energy action fields are twofold: to reduce the energy demand as much as possible, while trying to pursue the principle

Fig. 2 The SDGs related to the energy and buildings initiatives at Politecnico di Torino

of self-sufficiency. Following these premises, here is a list of the main initiatives PoliTO is pursuing and will pursue in the next future:

- Increase energy savings
- Detect anomalous electrical loads during periods of inactivity (in particular due to lighting and ventilation)
- Map all indoor and outdoor lighting systems
- Replace at least the 50% of the total installed power with LEDs
- Replace the remaining 40% of old windows with new high-efficiency ones
- Systematize data collection and monitoring of energy consumption of major carriers through the Living LAB structure
- Communicate achievements and engaging audience through dedicated on line channels and national/European campaigns.

All these actions can be mapped along the SDGs 7, 9, 10, 11, 12 and 13, as illustrated in Fig. 2.

5 Mobility and Transport

Sustainable mobility from and to the university campuses and its five metropolitan poles means to guarantee to all PoliTO's employees and users the availability of various transport modes. PoliTO is not only committed to propose new vehicles, services and systems, technologies, innovative ICT applications for urban mobility plans, but also to promote them in mobility management activities of Turin City Council.

Solutions including new transport modes, alternative energy sources beyond fossil fuels, the collection and the dissemination of information to help mobility are believed to be the path for sustainable mobility actions, in collaboration with the Turin delegated public authority, essential interlocutor when planning the public transport services satisfying the university needs and the latest solutions for shared transport systems.

Turin and its hinterland is the only area in Italy, one of very few in Europe, to engineer, design and implement the various transport systems and vehicles (by road, rail, rope, air and water), along with the relative road and multimodal control (for road, rail, rope, aircraft) using a strong component of technological innovation, ICT, recognizable in ITS (Intelligent Transport System).

Fig. 3 The SDGs related to the mobility and transport initiatives at Politecnico di Torino

Based on these premises, monitoring the mobility of PoliTO users is the first step to understand what to do for:

– the promotion of quality, safety, efficiency and awareness inside and outside of the campus;
– regulating cycle paths and car parking areas;
– improving relations between all poles of the campus and the City of Turin.

All these actions can be mapped along the SDGs 7, 9, 10 and 11, as illustrated in Fig. 3.

6 Urban Outreach

This actions field includes two fundamental focuses: a first one, towards the city and the society, and a second one, directed to PoliTO's internal community.

With regard to the first one, a strategic point of the urban outreach strategy of PoliTO is the preservation of existing facilities and buildings as well as to increase the recognition of urban places used by university users (buildings, paths, bars, study rooms etc.) and to strengthen of the sense of belonging in the city of Turin. PoliTO' sites are located all over the metropolitan area, offering a widespread and multi-polar system of services, which are highly interconnected and permeable with the local resources, including public and private companies and institutions of all levels. The dialogue between university and local authorities is encouraged by PoliTO's board of directors in order to support the development of common strategies to feed local service companies and services to the city users, especially the students enrolling every year from many different countries.

In relation to the aspects outlined in the "campus settings" section, the reuse of historical building like the Valentino Castle, as well as the refurbishment of former industrial sites, like Mirafiori and Lingotto campuses, outline the importance of PoliTO in the urban valorisation of green, brownfields or restricted areas, now available to the citizens, including students, employees and local residents.

The action field directed to PoliTO's internal community is a second important focus of Urban outreach strategy. In line with recent trends in the sustainability science, great attention is paid to quality of life and environmental responsibility of PoliTO's campus operations. For the PoliTO's community, being sustainable

Fig. 4 The SDGs related to the urban outreach initiatives at Politecnico di Torino

means focusing not only on the environment but also on the welfare of those who live inside the university (students, faculty, technical—administrative employees). PoliTO develops projects to improve its employees' recreation and physical well-being, to promote safety, health and welfare, education and awareness and equal opportunities; to provide tax assistance and cultural services, to optimize the use of public and green areas. Finally, PoliTO believes that a major role of university in contemporary society is to make people aware of human impacts in contemporary climate change. Therefore, a vital role is played by the teaching, training and the knowledge exchange activities delivered by our academic staff, spreading sustainability culture at local, national and international levels. All these actions can be mapped along the SDGs 3, 4, 5, 8, 11, 12 and 16, as illustrated in Fig. 4.

7 Food, Water and Waste

This dimension is twofold: on the food and wellness side, PoliTO is committed to promote the sustainability of the agro-food chain (energy saving, re-use of surplus) and local and traditional products and to encouraging guidelines for catering providers within the university in terms of contract and procurement (materials used). About waste management, PoliTO is committed to reduce/rationalize waste production, thus reducing its environmental impact following the "reuse-recycle- reduction" approach. To this end, PoliTO aims to increase the efficiency of both disposals and purchases, looking towards a full closure of the life cycle of the product in a sustainable way. This dimension of a sustainable university represents the reality of the campus in terms of environmental impact concerning waste; an entity such as PoliTO has an important influence on the city from this point of view and on users themselves (primarily students) who often are not educated or aware enough in terms of disposal and recycling.

Based on the current conditions, one of the PoliTO's absolute priorities is to face the situation trying, on one hand, to reduce the quantity of material where possible, while on the other hand continuing along the road of awareness and informative campaigns, creating ecological islands for recycling and other activities in order to educate generations of students and young adults living in the university and properly train the adults of tomorrow towards sustainable development. All these actions can be mapped along the SDGs 2, 3, 4, 6, 12, 14 and 15, as illustrated in Fig. 5.

Fig. 5 The SDGs related to the food, water and waste initiatives at Politecnico di Torino

Fig. 6 The SDGs related to the green procurement initiatives at Politecnico di Torino

8 Green Procurement

Materials for the university and its employees are bought following the green public procurement guidelines, in order to respect the environment without forgetting the cost effectiveness of supply. The sustainability of Politecnico in this regards refers indeed to all its purchases—i.e., paper, food and beverages, cleaning products, IT products and goods of any kind—and part of the waste.

The offices in charge of the purchases are obliged to do the best possible sustainable choice according to two protocols: one of the Ministry of Environment and one born from an initiative of the Province of Torino with ARPA, which is also joined by the City of Turin. The university spent about 10 M € in 2015, of which over the 54% is conform to GPP protocols. The Green Procurement actions included are:

- GPP Protocol adherence (Green Public Procurement);
- Use of ecological cleaning products;
- Use and purchase of "green" information technology products;
- Initiatives to recover and reuse printed paper;
- Training courses for staff on the use of "green procurement".

All these actions can be mapped along the SDGs 12 and 13, as illustrated in Fig. 6.

9 Communication

The creation of a communication plan for the Sustainable Campus Initiatives is a transversal action supporting all the previous ones. It encompasses the design of national/international events such as the sustainability week (promoted by AsviS), the promotion and communication inside and between the different areas of the Green Team via video/websites/web apps), the activation of specific thesis on the topic of sustainability marketing and communication, the joining of sustainable campus

Fig. 7 The SDGs related to the communication initiatives at Politecnico di Torino

networks and surveys to understand the degree of knowledge of the team and of the actions carried out by the different members.

All these actions can be mapped along the SDGs 4 and 17, as illustrated in Fig. 7.

10 Discussion

The SDGs mapping exercise over current and forthcoming action of the Politecnico di Torino Green team was very helpful made visible all the strengthening and weakening relationships among all the different fields of action. Being a technical university, the results highlight that the expertise and the actions are of course polarized toward the SDG 7, 9, 11 and 12. That implies that technology is being considered as the enabling factor for the implementation of the other SDGs, and in particular on the overarching SDG 13 on climate change mitigation and adaptation. This relation is bidirectional, too, in the forthcoming strategy of PoliTO, meaning that the struggle against climate change is believed to be positively driven by the deployment of sustainable energy services, and that the integration of climate change measures into national policies positively contributes to the deployment of renewable energies and energy efficiency measures.

The risks embedded in this direction, not touching for instance the 1, 2, 5 or 16 SDGs (End poverty in all its forms everywhere, End hunger, Achieve food security and improved nutrition and promote sustainable agriculture, Achieve gender equality and empower all women and girls, Promote just, peaceful and inclusive societies), are that the message the Politecnico could be giving to the students is that it is enough to just rely on technology to solve societal challenges.

A lacking SGD, for instance, is the 10th: "Reduce inequality within and among countries", which is crucial in the new UN agenda in order to ensure an equal and just progression toward a better quality of life for everybody on this planet (Chelleri et al. 2015; Escobedo et al. 2015; Mitlin and Satterthwaite 2012). That impedes to "glue" all the other objectives toward a just dimension in the distribution of the benefits out of innovation and technology investments. However, one of the reason for this polarization can be the fact that the mapping exercise has not been extended to the activities related to the so called Third Mission, where a number of initiatives related to cooperation are undertaken. Nevertheless, such mapping exercise allowed highlighting "black spots" in the current Green Team activities, both in collecting and giving a direction to existent PoliTO initiatives.

Another important opportunity underlying in the SDGs set is the need for collaboration for sustainability, which, from the analysis of the current structure of PoliTO, is still slow in its implementation (Leal Filho et al. 2018). To this extend, the mapping exercise did not include initiatives such the recent interdepartmental research centers, merging different disciplines. Indeed, according to the objectives of its Strategic Plan, PoliTO tried to turn the interdisciplinary collaboration among different technological and scientific fields into something more systematic. This strategic objective was put into action through the establishment and the funding dedicated to the so-called Interdepartmental Centers.

Through some physical and organization temporary platforms (3/5 year of lifetime), researchers belonging to different Departments interacted and cooperated with the aim of combining competences and producing knowledge in the field of the so-called breakthrough technologies; making the reputation and the visibility of University grow in the areas of strategic interest at a local and a national level; enhancing relationships with the most prestigious international institutions. The Interdepartmental Centers turned to be the result of two different selection approaches. In the first approach (called Top Down), the University Governing Bodies performed the role to detect the strategic topics (Energy, Additive Manufacturing, Mobility; Urban Challenges/Cultural Heritage, Data Science/Big Data and Internet of Things), where PoliTO is considered to be leader at an international level.

Within the same five thematic fields, other five interdisciplinary groups of researchers were created and involved in the second approach (called Bottom Up), where they proposed interdisciplinary research topics autonomously. The results are therefore market-oriented, and not SDG oriented, meaning that it will be difficult to implement the implicit logic of SDGs, where the goals depend on each other and not by financial leverages. If PoliTO and the other technical universities do not undertake the real challenge behind the SDGs strategic guidelines, it will lost the opportunity to be a critical stakeholder in shaping the future of University as the driving force for a low carbon, just and human society.

A last issue popping out from the mapping exercise was that, apart from the communication fields, none of the working team is effectively collaborating with the others in pursuing some concrete objectives. The SDG's underling need of collaboration is a crucial to achieve a common agreement for deciding a direction to take for funding distribution and organizational change. Materiality matrix, focus groups and workshop may favor the creation of concrete of goals adapted to a university dimension, where, for instance, the SDG 3, "Good health and well-being", can be scaled to a local dimension and be translated into welfare initiatives for students and staff, and in turn be connected to SDG 11 initiatives on teaching urban models fostering active lifestyles and architecture regenerative sustainability (Brown 2016; Sonetti et al. 2018).

Collaboration is also indispensable in current European research funding policy. In Horizon 2020, collaborative research is at the core of its Societal Challenges pillar. Here, the Commission have identified seven challenges which are of pressing, international concern, and which, as such, require collaboration to be addressed. This collaboration will not only span countries, but disciplines and sectors too, to nurture a "collective" consciousness toward the agreed (sustainable development) goals. Working toward a common goals also fosters creative skills and mindsets are indispensable in a workforce that must be responsive to change and capable of finding new solutions to complex problems. The World Economic Forum itself has identified social abilities such as coordinating with others and persuasion, as well as complex problem-solving skills, as essential in the knowledge-based workplace of the near future.[2] Also, according to the European Commission's new Entrepreneurship Competence Framework, entrepreneurial education includes life skills as well as business skills. It means learners can act upon opportunities and ideas and transform them into value for others, whether financial, cultural, or social (Kim 2011).

The problem is indeed not in the "amount" of knowledge the University transfer to students. The problem is a knowing-doing gap: a disconnect between our collective and our collective actions. These gaps and divides are amplified by the silos structure of our key institutions and the mindset of the decision makers that operate inside them (Scharmer 2018). A collaborative group of departments or students formed around a real challenge (that can come from a company, institution or from the students themselves) will chose to learn certain skills or knowledge or do research on a tailor-made base (Hogg et al. 2004; Kleine et al. 1993; Turner and Reynolds 2001). This approach stimulates a learning by doing approach, making knowledge and skills acquired relevant and applicable to the concrete goal achievement, besides contributing to the full development of an autonomous, supportive, responsible and committed person with an entrepreneurial mindset. At the end of the university path, students could have made a real positive impact on society and the University can be part of an educational system helping young people to develop their full physical, intellectual, emotional, social and spiritual capacities as individuals and as members of society, and thus contribute to the development of a better world (Fink 2013; Magolda 2004; Pizzolato 2003).

11 Conclusion

Adopted by the UN General Assembly in 2015, the agenda of the 17 Sustainable Development Goals (SDGs) represents a new coherent way of thinking about how issues as diverse as poverty, education and climate change fit together; it embeds economic, social and environmental targets in an holistic way. Implicit in such SDG logic is that each goal relies on another, although there are no clear ways to measure this intersection. International negotiations are obviously one trial table of these trade-offs. Universities, with their broad responsibility in the creation and dissemination of knowledge and their exceptional position within society, have a crucial role to play in the achievement of the SDGs and in understanding the complexity underling them, since they can help to demonstrate the university impact on society, shape

[2] https://www.weforum.org/agenda/2018/04/education-systems-can-stifle-creative-thought-here-s-how-to-do-things-differently.

an SDG-related education, build new partnerships, access new funding streams, and redefine the strategic plan of a university. This paper explores the way Politecnico di Torino maps its actions through the lens of a mission-based university, where SDGs can restructure and update the whole knowledge transfer approach to students and among staff. Being a technical university, results highlight that the expertise and the actions are of course polarized toward the SDG 7, 9, 11 and 12. That implies that technology is being considered as the enabling factor for the implementation of the other SDGs, and in particular on the overarching SDG 13 on climate change mitigation and adaptation. While a large number of actions related to Energy and buildings, Mobility and transport, Urban outreach, Food, water and waste, Green procurement and Communication are already mapped, even if "ex post", on almost all SDGs, these vertical actions need to be fostered by transversal and multidisciplinary "engagement" actions, coordinated and supported by administrative members, researchers and student representatives attentive to the wider impacts that fall into the "third mission".

This transition toward a collaborative model is still difficult, since departments and administrative unites operate in silos and the leader's agenda does not allow a real flexible and adaptable model to feed in. Researchers and administrators also lack tools to identify which interactions are the most important to tackle (AI and data mining still need a human touch to be effective in supporting the decision making process). The focus on "technical" SDGs demonstrate that PoliTO organizes its activities and research investments in technology innovation for results in mitigation scenarios, digital partnership with private companies and alignment with the major market trends. In order to understand the existing trade-off between SDG 7 and 9 and the other SDGs, further research is needed to study the directionality of each interaction in terms of counteracting/enabling other objectives. To make coherent policies and strategies, the PoliTO board of directors may need a rubric for thinking systematically about the many interactions, beyond simplistic synergies and trade-offs, in order to quickly identify which internal and external group of stakeholders could become their allies and which ones they will be negotiating with in the path toward a sustainable university.

Lastly, the SDG's underling need of collaboration is a crucial to achieve a common agreement for deciding a direction to take for funding distribution and organizational change. Materiality matrix, focus groups and workshop may favor the creation of concrete of goals adapted to a university dimension, where, for instance, the SDG 3, "Good health and well-being", can be scaled to a local dimension and be translated into welfare initiatives for students and staff, and in turn be connected to SDG 11 initiatives on teaching urban models fostering active lifestyles and architecture regenerative sustainability.

Given the size of the task of achieving the SDGs, and the critical role universities have in supporting and delivering on them, there is an urgent need for the sector to accelerate insights on the SDGs complementarity and prioritization, and this mapping exercise provides interesting stimula to redefine current models of education.

The difficulties we have in meeting today's global challenges, such as implementing the 17 Sustainable Development Goals (SDGs) worldwide, are not caused by a knowledge gap, but a lack in the collaborative culture in the strategic plans of universities. The SDGs lens of a mission-based approach can be a precious occasion to restructure and update the whole knowledge transfer approach in the higher education institutions, helping young people to develop their full physical, intellectual, emotional, social and spiritual capacities as individuals and as members of society, and thus contribute to the development of a better world.

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Achieving Excellence in Sustainable Development Goals in Sunway University Malaysia

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Abstract The Jeffrey Sachs Center on Sustainable Development (JSC) was established in 2016 to promote United Nations Sustainable Development Goals (SDGs), with a generous grant of USD 10 million from the Jeffrey Cheah Foundation. To enhance SDG 17: Partnerships for the goals, JSC has successfully conducted a series of well attended public lectures and workshops among Asean ministers, senior government officers, private enterprises and the public. Three additional core SDGs are identified for implementation: SDG 3: Good Health and Well-being; SDG 6: Clean Water and Sanitation; SDG 13: Climate Action. This paper outlines research and community outreach undertaken by JSC, in collaboration with local and international partners, to develop competences, expertise and talents in SDG 17 and three other core SDGs identified. On SDG 3, JSC advises Malaysian Ministry of Health in formulating model DEER for licensing of dengue vaccine Dengvaxia based upon a set of five criteria: safety, efficacy, equity, affordability and cost effectiveness. On SDG 6, JSC conducts field and laboratory experiments coupled with simulations using model E2Algae to implement effective measures for controlling eutrophication in a lake near campus. SDG 13 on climate action is intimately connected to SDG 14: Life under water and SDG 15: Life on land, viewed in the perspective of mangrove conservation.

Keywords Sustainable development · Good health · Clean water · Climate action · Mangrove

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1 Introduction

Developed to succeed the United Nation (UN) Millennium Development Goals (MDGs, 2000–2015), the UN Sustainable Development Goals (SDGs, 2015–2030) was adopted in January 2016 (United Nation 2015), as a template for sustainable development globally. The SDGs, officially known as "Transforming our world: the 2030 Agenda for Sustainable Development", consist of an intergovernmental set of 17 goals, 169 constituent targets and 230 indicators. Each of these SDG targets is designed to meet the criteria for SMART (specific, measurable, ambitious, realistic, time-bound) for them to be useful and for which the achievement can be objectively evaluated (Maxwell et al. 2015). These SDGs stipulate global sustainability benchmarks that apply across diverse sectors and national contexts, allowing public and private sectors to orient and evaluate their activities, strategies, and business outcomes (Sullivan et al. 2018). The SDGs, while not legally binding, offer a pathway for countries to mobilize efforts to end poverty, address climate change, promote efficient use of energy and resources, pursue innovation and secure equitable livelihoods for all people (United Nation 2015). A major goal for business entities such as the Sunway Group is to eliminate carbon emissions, reduce waste, water and fossil fuel use across its supply chains. This can be achieved by integration of sustainable development with industrial ecology and business strategy. As social licence to operate is critical to corporate survival, Sunway Group can and must derive competitive advantage by integrating social-ecological management activities with its business strategy (Hart 1995; Hart and Dowell 2011). Poverty alleviation, biodiversity conservation, and sustainable supply chains are critical factors for success (Hahn and Kühnen 2013). This can be achieved by embracing a more holistic approach to business strategic model, and by enhancing value in human and natural ecosystems for the long term (Sullivan et al. 2018). Sunway University embraces the fundamental SDGs articulated for the business sectors; with JSC pursuing research and outreach activities to complement the efforts by the business sectors. This paper presents a brief overview on the achievements, limitations and future strategy to sustain the vision and support the mission of JSC as an advocate and implementer for SDGs. Four core areas of competence in SDGs that the authors have pursued are: (a) SDG 3: good health and well-being, (b) SDG 6: clean water and sanitation, (c) SDG 13: climate action and (d) SDG 17: partnership for the goals. These four SDGs are certainly not stand-alone goals divorced from the other SDGs. For example, SDG 13 is intimately connected to SDG 14: life under water (the ocean goal) and SDG 15: life on land (the terrestrial goal), viewed from the perspectives of mangrove forests in mitigating climate change impacts. This connectivity is established as mangroves occupy areas common to both ocean and terrestrial habitats.

2 SDG 17: Partnership for the Goals

SDG 17: Partnership for the goals, aims to strengthen the means of implementation and revitalize the global partnership for sustainable development. To cultivate partnership for the goals, JSC actively promotes SDGs advocacy, community outreach, research and training across the nation and across the ASEAN region by ways of workshops, seminars and training courses. Notably, "*The ASEAN ministers workshop 2017 on SDGs*" was conducted on 25–26 April 2017 at Sunway University Malaysia, Kuala Lumpur. The aim is to provide a regional platform for the nations of Southeast Asia to share and improve national strategies, and to formulate a regional mechanism to implement the UN SDGs. The Workshop seeks to empower ASEAN members to improve their development plans and reorder their implementation priorities to achieve SDGs. More than one hundred participants took part in this workshop, including several ministers, senior government officers, non-governmental organizations (NGOs) and the public.

"*The Executive training course on leaders in sustainable development: Empowering leaders to elevate the region to the forefront of global SDG achievement*" was conducted on 30–31 October 2017 in Sunway City, Selangor, Malaysia. The world's leaders have, in 2015, committed to adopt the UN 2030 Agenda and to collectively pursue the 17 SDGs and 169 targets (United Nation 2015). Two years on, these leaders are exploring all prospects of making the achievement of the SDGs a reality within their national boundaries and beyond, as they confront national and transnational concerns that stand in their way. Professor Jeffrey Sachs of Columbia University led a team of top experts in Sustainable Development practices to teach this course. This course will equip leaders in Malaysia and countries in the ASEAN region and beyond, with the insights and customised approaches for sustainable development programming, policy interventions and multi-stakeholder collaborations. The goal is to galvanise sustainable development that will safeguard the well-being, peace and prosperity in their respective constituencies for generations to come. A total of more than 40 participants took part in this training course, more than the anticipated participation. "*Leaders in sustainable development*" will allow top leaders to gain clarity on their roles in bringing about meaningful change. They will be guided by world-class faculty, led by Professor Jeffrey Sachs, and assisted by best-in-class practices in the field of sustainable development. Upon completion of the program, they will become a part of a global network of the latest knowledge and ideas in the fast-growing field of sustainable development. They will grasp new perspectives and develop a solid appreciation of the key opportunities for countries and organisations. They will gain access to institutional frameworks and tools that can be immediately applied to SDGs. They leverage upon a collaborative environment that promotes partnerships between participants from the public and private sectors.

3 SDG 3: Good Health and Well Being

SDG 3: Good health and well-being, aims to ensure healthy lives and promote well-being for all at all ages. Focused global attention is needed to combat and end long-term epidemics of infectious diseases. For decades, humanity has been plagued by dengue, HIV, tuberculosis, malaria, hepatitis and other neglected tropical diseases. This SDG 3 can be achieved by the expansion of universal health coverage for all. A prerequisite is a firm commitment to social equity and an unequivocal respect for ethics and human rights (Raviglione and Maher 2017). Achieving good health and well-being for all, the salient goal of SDG 3, is one of the most compelling global challenges. Subscribing to SDG 3, the Malaysian Ministry of Health (MOH) is currently evaluating the licensing of dengue vaccine Dengvaxia. Vaccine is a control measure adopted to complement other dengue control programs, such as mosquito control, disease surveillance and case management. Dengue exerts heavy disease and social-economic burdens on tropical countries in Southeast Asia (Shepard et al. 2013), including Malaysia (Shepard et al. 2012). The second author is invited by MOH to provide key scientific and economic advice to MOH in formulating a pharmacoeconomic model for transparent decision-making. Guided by the aspiration of SDG 3 and World Health Organization (WHO) guidelines, the research team devised a set of five criteria consisting of safety, efficacy, social equity, affordability and cost-effectiveness as a basis for evaluation. This licensing exercise consists of two components; one is to determine whether Dengvaxia is safe and the second is to establish a price threshold that Malaysia considers highly cost-effective, following WHO criteria (WHO 2012). WHO advocates the principle of harmonizing equitable and cost-effective prevention measures via vaccine and behavioural adaptation. This is complemented with adequate entomological and epidemiological surveillance, coupled with good case management within existing health care systems. A fundamental underlining obstacle in dengue vaccine development is the fact that dengue is caused by *four* distinct but related viruses (DENV 1–4), transmitted primarily by the *Aedes aegypti* mosquitoes (Coudeville and Garnett 2012). The *Aedes* mosquito ecology promotes the co-circulation of these four related virus serotypes, in densely populated and unhygienic urban conditions. Co-circulation causes a heightened risk of sequential infections with increased severity in a subsequent infection. The failure of vector control such as the release of genetically modified (GM) mosquitoes to reduce dengue incidences has put additional pressure on the need for vaccine.

The mosquito field experiments jointly conducted by Oxitec and the Malaysian Medical Research Institute beginning in 2011 in Bentong, Malaysia *failed* to confirm the efficacy of GM OX513A male mosquitoes produced by Oxitec to suppress wild mosquito population. As the male GM mosquitoes will eventually die and as their offsprings are designed to die before maturity, the release of GM mosquitoes must be performed repeatedly over extended period, a critical flaw of OX513A. The second author was invited to participate in this research to verify the effectiveness of this GM release method for vector control. A numerical simulation model known as DEER (Dengue Encephalitis Eradication Routines) was developed to examine the efficacy of GM OX513A male mosquitoes as a mosquito control measure. Extensive simulations concluded that OX513A mosquitoes will *not* be effective in controlling wild mosquito population as a vector control measure (Koh et al. 2011). For sure, GM mosquito field release is very expensive, is not sustainable economically and not feasible logistically. The authors recommended that the GM release experiments in Malaysia be terminated. By mid-2015, the minister of MOH decided to terminate this experimental study, citing similar reasons. The GM mosquito release can only control mosquito population over a *small* area, while dengue is *everywhere,* the minister declared. To be useful as a vector control measure, the GM mosquitoes must be released across very large areas over an extended period. This will impose immense financial burdens far beyond the capability of the government, and is *not* consistent with SDG 3. Further, the ecological impacts have never been studied at all, contradicting SDG 15.

Because effective mosquito control has been proven to be difficult to sustain, dengue vaccine is highly desirable in an environment of persistent dengue epidemic. However, the vaccine must be safe, socially equitable, affordable, cost-effective and efficacious. Price is the most important factor influencing vaccine sustained adoption in low and medium income countries (LMIC), once safety and efficacy are assured. An extensive literature review reveals that (a) most vaccines are affordable, readily accepted, and sustainably adopted if they are priced below USD 1.00 in LMIC and that (b) dengue vaccine can be sustainably produced at around USD 0.50 per dose with mass production (Mahoney et al. 2012). As the developing LMIC countries find it increasing difficult to cope, sound economic fundamental is essential in justifying pricing decisions to introduce and sustain vaccination (Beatty et al. 2011). A WHO study found that vaccine is cost-effective in developed countries at the price of USD 7.64 per dose, weighted average for public and private sector including administrative costs (Beatty et al. 2011). The fair price threshold for LMIC should therefore be much lower. Another recent study in Singapore concluded that a dengue vaccine involving three doses and conferring ten years of immunity would be cost-effective at a price threshold of USD 95 per dose, given Singapore GDP per capita of about USD 55,000 (Carrasco et al. 2011). Whether this high price threshold is affordable or socially equitable for Singapore was not a concern for the researchers. This attitude contradicts the aspiration of SDG 3 that aims to sustain good health for *all*. It is undeniable that this price threshold of USD 95 per dose is not affordable and not socially equitable for Malaysia, given the much lower GPD per capita of USD 11,000 for Malaysia. To subscribe to the aspiration of SDG 3, the study team devised a combination of five criteria mentioned earlier as a basis for a transparent valuation of threshold price. The study concludes that a socially equitable and highly cost-effective price threshold in Malaysia for dengue vaccine is USD 5 per dose (Koh et al. 2017). This socially equitable price threshold will be widely affordable to and readily adopted by the Malaysian consumers. This will ensure sustained and predictable consumption, which in turn will allow producers to fine-tune mass production to reduce the costs of production and distribution to less than USD 1.00 per dose. This will be a win-win scenario for both consumers and vaccine developers. Further, the study team has discovered that the current version of Dengvaxia has a hidden danger (Koh et al.

2017). The person vaccinated by Dengvaxia might develop a more severe form of disease if that person had not been previously infected by dengue. This increased risk of Dengvaxia has recently been acknowledged by the MOH and Sanofi Pasteur in separate official statements in December 2017. The Malaysian MOH authority is understandably very cautious about granting full registration to Dengvaxia. Instead MOH has decided to confer only a conditional one-year registration for Dengvaxia, pending further study by the vaccine developer Sanofi Pasteur. No Dengvaxia has been sold nor used by Malaysian consumers. By contrast, the Philippines has conducted a massive vaccination program, with 780, 000 persons having been vaccinated with Dengvaxia since 2016. The Philippine government has suspended further sales of the vaccine and is contemplating legal procedure against Sanofi Pasteur.

4 SDG 6: Clean Water and Sanitation

SDG 6: Clean water and sanitation, aims to ensure availability and sustainable management of clean water and sanitation for all. This requires good management dedicated to improving water quality, to increasing water-use efficiency across all sectors, and to restoring water-related ecosystem functions (Kadi 2016). To support SDG 6 by developing relevant skills and competences, the authors conducted research on a small lake known as Sunway Lagoon (SL), located near the campus. Quarterly water quality surveys and monthly water quality samplings were conducted. Water samples were collected from the lake at three water depths: surface (0.5 m), mid-depth (3.5 m) and bottom (7.5 m). Water quality parameters sampled include temperature, pH, BOD, dissolved oxygen (DO), ammoniacal nitrogen, nitrate nitrogen, phosphorus, Chlorophyll-*a* (Chl-*a*), total coliform and *E. coli*. The lake is currently classified as eutrophic, with high Chl-*a* concentration and low DO, indicative of water quality status of Class III (Koh 2017). The goal is to rehabilitate the lake water quality to a level adequate as a source of usable water, after adequate treatments. This goal would help increase water adequacy and enhance water security for the Sunway City. SL is vulnerable to accumulation of nutrients and other pollutants originating from the surrounding human settlements. Of concern is the high level of Chl-*a* recorded, between 10 and 25 μg/L, indicating a highly eutrophic lake condition. In general, an oligotrophic lake (clear water) should have Chl-*a* level below 2 μg/L (Teh et al. 2008); while a meso-eutrophic lake should have Chl-*a* between 2 and 9 μg/L. Levels of Chl-*a* exceeding 9 μg/L is considered eutrophic and undesirable. Dissolved oxygen remains low. Seven aerators are currently in operation to provide additional DO to the water to support fish and other aquatic animals. Lake sediment contains high levels of total nitrogen, total phosphorus and total organic contents. In support of the aspirations of the UN SDGs, SL management has engaged the authors to improve water quality in SL to fulfil SDG 6 goal of clean water and SDG 14: life under water. The build-up of nutrients in the sediment layers could lead to nonlinear interaction between the sediments and the water column. This phenomenon of self-reinforcing feedback loop can intensify algae growth towards a bifurcation tipping point leading to hyper-eutrophication (Shan et al. 2014; Koh et al. 2018a). Sustainable and cost-effective remediation measures will be developed to improve water and sediment quality in SL. It has been decided to rehabilitate Sunway Lagoon water quality by constantly and consistently removing accumulated nutrients and other pollutants by simple and sustainable means. Lake water at depth of 7.0–7.5 m will be drained regularly and replaced with rainwater. The drained water with high nutrients will be used for in-house vegetation watering. This rainwater harvesting and recycling of nutrient rich lake water as fertilizer is consistent with the basic concepts of SDGs.

Recent sampling results also suggested a possible negative role of high fish density on SL water quality. High fish density will reduce DO, increase nutrients and BOD via fish respiration, fish meal residuals and excretion. A research was therefore conducted in a fish pond G3 located within Sunway University campus. The DO levels were very low, between 0.5 and 1.2 mg/L, causing some fish kill over the night time (Koh et al. 2018b). Nitrate (NO_3) levels were very high at around 20 mg/L, reflecting water quality indicative of aquaculture farms (Samocha et al. 2010). The low DO and high NO_3 reflect high eutrophication due to high levels of nutrients from fish meals and excreta. Sunway Lagoon fish biomass density should be kept far below 0.1 kg/m^3. To develop relevant skills and competences in implementing SDG 6 and 13, final year project students were engaged to perform laboratory, field and simulation studies. The simulation model used is an in-house model E2Algae (Teh and Koh 2013). Engaging students, technicians, academics and SL management in this research helps to integrate various components of the Sunway ecosystems into one holistic entity, fulfilling SDG 17: Partnerships for SDGs.

5 SDG 13: Climate Action and Mangrove Conservation

Climate change is characterised as a pattern of extreme weather changes and accelerated sea level rise (SLR) that can pose threats to many SDGs. Hence, effective SDG 13: Climate action is urgently required. Climate change is commonly believed to be the primary reason why natural disasters such as severe floods, extensive droughts, treacherous hurricanes and violent storm surges happen more frequently and with more intensity than previously. Sea levels across many parts of the globe have been rising on average by about 3 mm annually due to warming climate. Malaysia is not spared from this global SLR phenomenon. Sea level measurements along the Malaysian coasts suggest that sea levels have been rising at a rate of 2.7–7.0 mm annually (NAHRIM 2010), affecting many Malaysian coastlines in Penang, Kedah, Kelantan, Sabah and Sarawak. Over the coming century, sea levels around the coastline of Malaysia are expected to rise 25.3–51.7 cm. Many low-lying coastal areas of Sabah and Sarawak will likely be submerged 43.2–106.4 cm below mean sea level by the end of the century. Scientists across multiple disciples are scrambling to avert this potential disaster that will affect millions of Malaysians, reduce agricultural and tourism outputs, and disrupt the national economy. It is therefore imperative that Malaysia take proactive steps now to minimize vulnerability to SLR by taking appropriate climate actions.

Research on the South Florida area indicates strongly that seawater inundation by storm surges and saltwater intrusion via groundwater diffusion into coastal groundwater will likely cause serious problems soon (Teh et al. 2013). This may lead to permanent salinization of fresh groundwater around South Florida (Jiang et al. 2012). The salinization of fresh groundwater will, in turn, have a negative impact on the growth and productivity of plants, negatively impacting food security. This threat to coastal groundwater resources and vegetation growth can be investigated scientifically by field monitoring, remote sensing technology and model simulations. And appropriate climate action can be developed to allow coastal communities to devise plans to cope with the potentially disastrous impacts of climate change. Achieving agricultural, food and water security, via climate action and adaption to climate change, is critically important for safeguarding humanity. Understanding the coupled relationship between surface and subsurface water is crucial for achieving sustainable coastal water resource utilization, particularly under the threat of climate change (Jiang et al. 2015). Research is conducted to avert this looming crisis by integrating science (hydrology, plant biology), technology (ICT, big data, computer simulations), engineering (coastal geophysics) and mathematics (model simulation, theoretical analysis) to drive climate action plan for addressing the impending crises posed by climate change (Teh et al. 2015). This research will inspire a new generation of young people and fresh graduates to undertake a sustained interest and solid commitment in integrating multiple disciplines (STEM: Science, Technology, Engineering, Mathematics) to seek long term solutions to real-world problems. An integrated simulation model known as MANTRA has been developed by the authors jointly with the United States Geological Survey (USGS) to integrate surface and subsurface hydrology, groundwater salinity and coastal vegetation growth dynamics. This model has the capability to predict the short- and long-term pattern of soil water quality and salinity changes and the potential impact on coastal vegetation in the affected areas. This MANTRA model is driven by existing climate observations and predicted future climate change scenarios (Teh et al. 2015). It might seem odd to think that a country like Malaysia can ever face critical water crisis. However, dwindling usable water resources decimated by anthropogenic pollution and unsustainable exploitation can pose a significant threat to water security. Increased salinity intrusion into surface and subsurface freshwater sources due to climate change has the potential to aggravate the situation further. Water scarcity, soil degradation and the loss of arable farmlands worldwide will have a profound influence on food security (Teh and Koh 2016). About 1.5–2 billion people worldwide rely on groundwater as their main sources of drinking water. Salt intrusion into aquatic ecosystems, consisting of rivers, estuaries, wetlands and deltas, low-land agriculture farms (especially rice) and coastal groundwater systems, can pose serious threat to freshwater resources. Climate change might result in whole ecosystem regime shifts, reduce food production and threaten livelihoods for critically affected regions. For instance, more than 20,000 ha of rice paddy fields in Japan were flooded with saltwater following the 2011 Tohoku tsunami. A year later, the soil in areas located within 3 km from the coast was still so heavily salt-laden that they are completely unsuitable for rice production. Rice production in these areas was halted for at least two years (Roy et al. 2014). The MANTRA model is currently applied to a research on analysing coastal groundwater and vegetation in two selected study sites near Kg. Pantai Acheh of Penang and Pulau Kukup of Johor. The goal is to predict whether saltwater intrusion and frequent storm surges due to monsoons coupled with SLR will have a long-lasting impact on sustainable fresh groundwater supply and on vegetation growth. This model offers a useful tool for sustainable management of coastal resources, both abiotic and living, along the interface between the seas and the land (SDG 14: Life under water and SDG 15: Life on land). For this research, the third author has been awarded the prestigious L'Oréal-UNESCO for Women in Science Malaysia National Fellowship 2017. Further, this research has received continuing collaboration and support over a decade from the USGS. The collaboration focuses on monitoring and modelling potential regime shifts in coastal vegetation in the Greater Everglades in Florida, in response to SLR and storm surges such as hurricanes. This research will soon be extended to other sites in the south-eastern coastal United States. This is a vivid example of developing relevant skills and competences in SDGs to "solving global problems with local innovations". This research has sparked keen interest among researchers in the wider Florida and beyond. MANTRA and associated simulation models will provide the solid foundation for ongoing USGS research programs on climate action (SDG 13). Research related to SDG 13 on climate action is an ongoing endeavour, that requires continuous commitment, constant attention, persistent effort, sustained funding and relentless passion.

Viewed from the perspectives of mangrove conservation and restoration, SDG 13: Climate action is intimately connected to SDG 14: Life under water (the ocean goal) and SDG 15: Life on land (the terrestrial goal). Mangrove conservation and restoration has been recognized as an important mitigation measure for climate action. It is perceived to be relevant to several other SDGs (Wood et al. 2018; Romañach et al. 2018), a topic for further deliberation in the remaining section, to highlight potential obstacles and synergies in the implementation of SDGs. The common habitats for mangroves, located at the interface between the open oceans and coastal lands, suffer from both the "tragedy of the commons" and the "tragedy of open access". Uncontrolled resources extractions and services utilizations have exerted strong pressure on these marine ecosystems. These abuses range from over fishing, unsustainable resource exploitations, and massive alteration of coastal zones for human settlements, to various forms of marine pollution. To counteract both tragedy of the commons and tragedy of open access, SDG 14 aims to conserve and sustainably use the oceans, seas and marine resources for sustainable development for the long term. SDG 14 and the targets within that goal, contribute to other SDG goals. Firstly, the ocean SDG target 14.7 aims to increase economic benefits to Small Island Developing States (SIDS) and least developed countries for sustainable marine uses. This is perceived to have positive impacts on virtually all SDGs (Singh et al. 2018), in particular on SDG 1 (no poverty) and SDG 2 (no hunger) and SDG 10 (Reduced inequality). Secondly, the ocean SDG target 14.4 aiming to eliminate overfishing, illegal and destructive fishing is a necessary condition for achieving a large number of other SDG such as

SDG 8 (decent work and economic growth), SDG 10 (reduced inequality) and SDG 12 (responsible consumption and production).

6 Discussion: SDGs and Ecosystem Services

Research and outreach on the four core SDGs 3, 6, 13 and 17 within Sunway University and Universiti Sains Malaysia has opened the window of opportunities to other fruitful collaboration. A discussion on potential research and outreach collaboration on related SDGs will be briefly explored in this section. Found mainly at the interface of land and the sea, mangroves are vulnerable to disturbances in the land-sea interface. Yet mangroves, and other marine ecosystems, can provide valuable ecosystem services to human well-being (Torres and Hanley 2017) and to the fulfilment of certain SDGs. This includes the protection of coastal and terrestrial habitats (Millennium Ecosystem Assessment 2005; Teh et al. 2009) and protection from disruptions from the oceans, both natural and anthropogenic. In a survey, ecosystem services are perceived to contribute to the achievement of 41 SDG targets. The provision of food and water, the maintenance of habitats and biodiversity, and the storage and sequestration of carbon (Dung et al. 2016) are perceived to each make contributions to more than 14 SDG targets, suggesting cross-target interactions. This may present opportunities for synergistic outcomes across multiple SDGs.

The ecosystem services provided by marine ecosystems include fish, fibre, fuel and coastal protection, on which over 1 billion people currently rely. Small-scale local artisanal fishery can boost social equity (SDG 10), provide inexpensive food and protein (SDG 1, 2), encourage sustainable economic growth (SDG 8) and support ecological sustainability at the local scale, supporting many SDG targets all at once (Chadwick et al. 2014). This conclusion was also reached from the ecosystem service research conducted on the West Coast Rock Lobster fishery within the Table Mountain National Park Marine Protected Area in South Africa (Ward et al. 2018). With a clear mandate to integrate social justice, economic viability and environmental objectives in the 17 SDGs, maintaining healthy ecosystems (Goal 14: life below water and Goal 15: life on land) is a prerequisite to achieving the 2030 Agenda for Sustainable Development that ensure post-2030 sustainability (Reid et al. 2017). Ecosystem health is the foundation for social and economic well-being, as the three pillars of sustainable development (just society, vibrant economy, healthy environment) are intimately linked. The tightly connected and synergetic ecological, social and economic outcomes will sustain strong incentives for compliance. Ample opportunity abounds for early-career scientists and social-economic researchers to approach economic-social-ecological integration from a trans-disciplinary perspective, spanning the entire society, economy and environmental spectra. The authors take pride in supporting the new paradigm shift that dictates that ecosystem health must be managed and maintained for its own sake, as well as for that of the human users and associated sectors, as they are all interlinked in a holistic entity.

The promotion of mangrove and other marine conservation and the enhancement of human well-being and livelihoods at the same time have been the two primary aspirations of the UN SDGs. Globally, management and policy had largely failed to ensure the conservation and sustainable use of mangrove and other marine resources such as corals and seagrasses. This failure might repeat in SDG implementation due to a myriad of similar reasons. A primary reason is the failure to integrate the differing spatial and temporal scales at which ecosystem services are provided (ecological provisional scale), with the scales at which the management, policy and utilization institutions operate (societal demand scale). For example, local resource users, operating at the faster demand scale, lack the incentives and institutional imperatives to consider and integrate into the slower ecological provisional scales of ecosystems, resulting in a mismatch between benefits and costs (Romañach et al. 2018). Research conducted in Indonesia and Brazil reported that social unrests occurred frequently over the failures in managing the conflicts between resource provision and utilization, and over the failure in integrating science with local community knowledge (Máñez et al. 2014). In Indonesia, the Segara Anakan Conservation and Development Project (SACDP), funded by the Asia Development Bank (ADB), in cooperation with the government of Indonesia, failed in integrating scientific research findings with local community knowledge, resulting in strong challenges and resentments from grassroots communities. The grassroots communities felt that the scientific sectors did not produce good problem-solving solutions, as it was perceived to be oriented towards the wishes of established elite communities. As expected, these projects failed to deliver theirs goals and failed to fulfil SDG 16 (peace, justice and strong Institutions) (Dharmawan et al. 2016). Ample examples abound worldwide to suggest that SDG implementations may encounter similar obstacles and may not be satisfactorily accomplished by 2030, unless these conflicts are well understood and adequately resolved. This calls for a new breed of thinkers, actors, communicators, educators, policy-makers and implementers, who are well versed in the intricacy and intrinsic conflicts embedded in SDGs. Working in good coordination with these players, JSC aspires to help implement SDGs within the stipulated time frame, a tall task for which JSC is designed to accomplish.

7 Conclusion

This paper presents a summary of the contributions of the authors in promoting and achieving the implementation of four core SDGs: SDGs 3, 6, 13 and 17. It provides a brief exposition on the achievements and efforts devoted to developing relevant skills, competences, expertise and talents in the four interdependent SDGs, within the context of university communities. It explores the important roles played by ecosystem services provided by nature in supporting the accomplishment of several SDGs. However, to achieve the UN SDG agenda by 2030, much more needs to be accomplished at a larger spatial-temporal scale. For example, efforts to eradicate dengue, malaria, tuberculosis and other emerging tropical infectious diseases (SDG 3, target 3.3) will require a suite of management tools from land use control, and management for pest and vectors control, to insecticide-treated bed nets and effective national health programs to educate and treat affected communities (Cartwright et al. 2013). Similarly, achieving clean water targets for large urban populations under SDG 6 will require a combination of installing adequate water treatment plants alongside effective catchment land use management for controlling water pollution. On SDG 13 that calls for appropriate climate action, the paper highlights vital ecosystem services provided by nature that mitigate climate impacts and support humanity basic needs and long term survival (Chadwick et al. 2014). These ecosystem services include providing food, cycling nutrients, regulating climate, and offering social-spiritual enrichment (Hoegh-Guldberg et al. 2015; Millennium Ecosystem Assessment 2005). They help to fulfil several SDGs such as SDG 2 (no hunger), SDG 6 (clean water) and SDG 13 (climate action). Valuing ecosystem services can empower a future of vibrant environments, robust economies and healthy people (Marre et al. 2015), consistent with the aspirations of the triple-bottom line of SDGs. Integrating ecosystem services into strategies for meeting the SDGs can help achieve many SDG goals and targets with more vigour and commitment. Innovative research is therefore highly desirable to estimate economic valuations of these ecosystem services for supporting decision-makers in achieving the SDGs. However, ecosystem services alone will be grossly insufficient and inadequate to achieve the ambitious SDG agenda. Ecosystem service management will need to be augmented with complementary technologies, and socio-institutional solutions to achieve targets over the SDG timespan (2015–2030). Understanding how these ecosystem services could support multiple SDG goals, including SDG 16 (peace, justice and strong institution), is essential for planning and implementing synergistic and cost-effective interventions (Wood et al. 2018). These ecosystem services are frequently linked to the same SDG targets, such as social justice, good health, clean water, climate regulation and wild lives that support recreation and tourism. JSC plans to offer postgraduate degree programs, promote community outreach activities, conduct seminars, training courses and workshops to inculcate good governance and to develop relevant skills and competences for achieving synergy in this myriad of interdependent SDGs. Table 1 gives an outline of these research and community outreach programs undertaken by the authors to develop relevant governance, skills, competences, expertise and talents in SDGs 17, 3, 6 and 13. It is hoped that this 4th World Symposium on Sustainable Development for Universities would serve as a good forum to stimulate coordinated endeavours and enterprises dedicated to the accomplishment of the UN SDG Agenda by 2030.

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Table 1 Summary of the selected projects and main findings relevant to SDGs implementation in Sunway University Malaysia

SDG	Projects	Partners	Relevance/Implication	Findings/Outcome
SDG 17: Partnership for the goals	ASEAN ministers workshop 2017 on SDGs	ASEAN	• To empower ASEAN members to improve their development plans and reorder their implementation priorities to achieve SDGs	• National strategies to achieve SDGs are presented and shared to formulate a regional mechanism to implement the UN SDGs • More than one hundred participants took part, including several ministers, senior government officers, NGOs and the public
	Executive training course on leaders in sustainable development: empowering leaders to elevate the region to the forefront of global SDG achievement	• Columbia University • Sunway University • ASEAN	• To commit to the adoption of UN 2030 Agenda and to collectively pursue the 17 SDGs and 169 targets • To equip leaders in Malaysia and countries in the ASEAN region and beyond, with the insights and customised approaches for sustainable development programming, policy interventions and multi-stakeholder collaborations	• Prof. Jeffrey Sachs of Columbia University led a team of top experts in Sustainable Development practices to teach this course • A total of more than 40 participants took part in this training course, more than the anticipated participation • At the end of the course, the participants will (i) grasp new perspectives and develop a solid appreciation of the key opportunities for countries and organisations, (ii) gain access to institutional frameworks and tools that can be immediately applied to SDGs and (iii) leverage upon a collaborative environment that promotes partnerships between participants from the public and private sectors

(continued)

Table 1 (continued)

SDG	Projects	Partners	Relevance/Implication	Findings/Outcome
SDG 3: Good health and well being	Efficacy of genetically-modified (GM) Oxitec mosquitoes for dengue eradication	• Sunway University • USM • MOH, Ministry of Health Malaysia	• To assess the effectiveness of release of Oxitec GM mosquitoes for controlling mosquito population	• The use of GM mosquitoes is not sustainable economically and not feasible logistically • It is recommended that the Oxitec GM release experiments in Malaysia be terminated. MOH accepted recommendation • Further, ecological impact of the release not well-studied
	Pharmacoeconomics study for Malaysia	• Sunway University • MOH • USM	• To appraise dengue vaccine Dengvaxia implementation in Malaysia • To evaluate and provide recommendations on the most cost-effective price per dose of dengue vaccine Dengvaxia by Sanofi Pasteur	• Recommended a set of five criteria consisting of safety, efficacy, social equity, affordability and cost-effectiveness as a basis for evaluation • The current version of Dengvaxia has a hidden danger for seronegative individuals • Conditional registration of Dengvaxia in Malaysia • Vaccine price is the most important factor, once the vaccine safety and efficacy are assured • Recommended dengue vaccine pricing threshold for Malaysia: USD5 per dose

(continued)

Table 1 (continued)

SDG	Projects	Partners	Relevance/Implication	Findings/Outcome
SDG 6: Clean water and sanitation	Remediation and conservation of Sunway Lagoon (SL)	• Sunway University • USM • Yunnan University • Vietnam National University	• To rehabilitate the lake water quality to a level adequate as a source of usable water, after adequate treatments • To help increase water adequacy and sustain water security for the Sunway City • To reduce/eliminate the use of man-made aerators, consistent with SDG 6 and SDG 14	• Possible negative role of high fish density on SL water quality • Within a decade, an undesirable scenario of hyper-eutrophic water quality cannot be ruled out • Need to constantly and consistently remove accumulated nutrients and other pollutants by simple and sustainable means • Lake water at depth of 7.0–7.5 m should be drained regularly and replaced with rainwater • The drained water with high nutrients can be used for in-house vegetation watering
SDG 13: Climate action and mangrove conservation	Sea level rise (SLR) impact on coastal groundwater and vegetation	• USM • USGS • University of Miami • Sunway University • UTM • FRIM	• To assess the impact of climate-change, SLR, on low lying coasts and atoll islands • To study the effect of salinity intrusion on coastal biodiversity and agriculture	• Groundwater and vegetation model MANTRA is developed for projection • Integration of STEM disciplines • Contribute towards achieving water, food and agriculture security

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EDS Integrated Approach for Sustainability (EDS-IA): Campus as a Living Laboratory Experience

Liliana Diaz and André Potvin

Abstract Since 2016, Institut EDS is developing a new integrated approach to facilitate collaborations between different disciplines and to reinforce the development of practical skills and key competencies needed to solve concrete sustainable development problems: the EDS-IA. It aims to contribute to the acceleration of the transition to a closed and cyclic development system, building on the most recent knowledge mobilization frameworks in the field: the concept of Planetary Boundaries, the concept of Social Floor, the Sustainable Development Goals, Key Competencies in Sustainability and Multilevel Governance. Despite the broad consensus and the robustness of the scientific knowledge underlying all these frameworks, they are not sufficiently known beyond their own field of knowledge. In order to facilitate their diffusion and their appropriation by all the disciplines and actors concerned with the transition to sustainability, EDS-IA integrates them in a diagram as a tool that can be adapted to different development challenges in different contexts. During its first year of implementation (2016–2017), researchers and student members of the Institute participated in a series of major co-creation activities along with staff university members, governmental organizations as well as representatives of civil society. They made a diagnosis of the sustainable status of the campus and imagined innovating solutions for a "Campus as a living laboratory" through operations, teaching, research, and community services. In the second year (2017–2018), the transfer of the EDS-IA started through similar workshops with a university partner in Senegal (UADB). This paper presents the theoretical and methodological frameworks of the EDS-IA and the results of the first two years during which universities have been imagined as living laboratories for SDG promotion and implementation.

Keywords Sustainable development · Participatory methods · Partnerships between academics and society

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1 Introduction: The Challenge of Mobilizing Disciplines Towards Sustainable Action

L'Institut Hydro-Québec en environnement, développement et société (Institut EDS)[1] has the mission to "promote a 360-degree vision of environmental and sustainable development issues by spearheading and conducting activities aimed at furthering, acquiring, and disseminating knowledge in order to mobilize stakeholders and generate tangible results for society". This mission builds on its role in supporting and developing interdisciplinary research at *Université Laval* as well as on innovations in education and knowledge sharing. Since its creation in 2004, with a generous support of Hydro-Québec, *Institut EDS* helps pool and drive efforts to better coordinate knowledge-sharing activities of its some 100 researchers, 400 student members, and research chairs and groups from most of the eighteen faculties of the *Université Laval*. Five interdisciplinary axes serve to weave collaborations: *climate change*, *biodiversity* and *water* representing three main global environmental challenges; *cities and territories* as a priority action level; and *governance* as a key for transition to sustainability. These axes correspond to the three interrelated components defining the "pillars" of sustainable development: environment, development and society.

When André Potvin became director of the Institute in 2016, he set up an approach that aims to facilitate collaborations between researchers and stakeholders, and he called it "EDS Integrated Approach" (EDS-IA). This approach is based on an understanding that environment, development and society—the three parts of the institute's name—are all variables in an equation defining a close cyclical system based on environmental limits. Thanks to the contributions of the many scientific disciplines, it is possible to understand and recognize the limits that natural cycles and resources flows should impose on human actions. It is also through the interdisciplinary work that we can imagine new and more respectful responses to human needs, according to environmental limits. In a teaching context, still very fragmented by faculty divisions, EDS-IA is used as a tool for designing educational activities for students from all the study programs[2] to contribute to develop Key Competencies in Sustainability (Wiek et al. 2011). Furthermore, by considering the different scales of intervention of each pillar, EDS-IA aims to help understand the challenge of multilevel governance, which can only be tackled through a concrete practice of interdisciplinarity (Hufty 2011). Ultimately, by mobilizing and strengthening the links between academics and a multiplicity of stakeholders, EDS-IA encourages the transformation of universities into living laboratories for the promotion and implementation of the Sustainable Development Goals (SDG).

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[1] www.ihqeds.ulaval.ca.

[2] There are almost 240 graduate programs at *Université Laval.*

2 EDS-IA Conceptual Framework: From a Linear to a Cyclical and Multilevel Model

Traditional development models have mainly been linear and open, responding only to short-term human needs and leading to a culture that degrades the environment. To express a vision of society that breaks with this model, we propose a representation of a cyclical process which focuses on the interactions between the three pillars of sustainability. This process is triggered by the multiple needs existing in society. The answer to these needs becomes tangible through artefacts of all kinds (goods, infrastructures, buildings) and results in the development of cities and territories. In turn, this development produces environmental impacts such as climate change, loss of biodiversity and alteration of the water cycle and aquatic environments (Fig. 1).

This cyclical vision forces us to rethink the needs of society according to the limits imposed by the environment. It also requires the introduction of new technologies and practices for reducing environmental impacts. This double exercise is at the heart of the EDS-IA since it aims to facilitate the emergence of new solutions to meet the essential needs of humanity, while integrating the respect of bio-geochemical cycles of our planet.

Moreover, in order to improve consistency and effectiveness of any intervention we need to take into account not only the interactions between these three pillars, but also with an between different scales of intervention at each pillar. Thus, in the social pillar, we must consider both individual and collective needs as well as institutions that regulate potential conflicts between needs and encourage behavioral changes. In the "development" pole, we need to consider all artefacts, goods and services produced to meet the needs of society. It goes from consumer goods, to the planning of territories, through that of cities. Regarding the environment, we must consider the links between ecosystems and the impacts of human actions on natural cycles, from

Fig. 1 Towards a cyclical vision of development

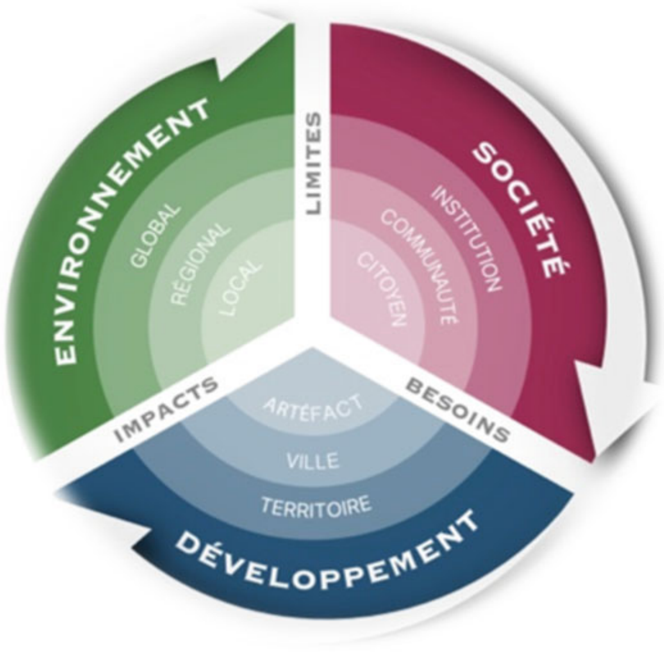

Fig. 2 The “ideation engine”

local to global. In order to tackle all these aspects, it is necessary to mobilize many disciplines around a given object of analysis. It is through this “interdisciplinarity in practice” (Hufty 2011) that this approach contributes to a better understanding of multiple issues related to sustainable development and encourages the emergence of new solutions. This is what we call the “Ideation Engine” (Fig. 2).

2.1 Systems Interactions

The EDS-IA is based on the assumption that a common understanding of the meaning of sustainable development is a prerequisite to improve the effectiveness of any collective effort. It is well known that, according to the definition of the WCED report, sustainable development contains within it two key concepts:

- the concept of ‘needs’, in particular the essential needs of the world’s poor, and
- the idea of limitations (WCED 1987).

EDS-IA come back on these concepts from the most recent frameworks for research and action in the field of sustainable development and integrates them in a conceptual diagram. Those frameworks are:

- Planetary Boundaries (Rockström et al. 2009a, b; Steffen et al. 2015)
- Social Floor (Raworth et al. 2012)
- Sustainable Development Goals (United Nations General Assembly 2015).

2.2 Planetary Boundaries

According to Joan Rockström's team, there are nine functional boundaries or thresholds beyond which biogeochemical flows can be irreversibly altered (Rockström et al. 2009a). We can grouped it into three trios, depending on the sphere in which they have the main influence: the atmosphere, the hydrosphere and the biosphere. These three spheres interact with each other and with the lithosphere. In the same way, boundaries' action also transcends a single sphere. Three functional limits primarily concern the atmosphere: atmospheric aerosol loading, stratospheric ozone depletion and climate change. Three others affect mainly the hydrosphere: chemical pollution, interference with the global phosphorus and nitrogen cycles, and global freshwater withdrawn. Finally, three others affect the future of the biosphere: ocean acidification, land-system change (owing to agricultural and urban land expansion) and biodiversity loss. We now know that boundaries concerning the rate of biodiversity loss, climate change and the nitrogen cycle have already been exceeded (Rockström et al. 2009b).

These functional boundaries are values established from the best of current scientific knowledge in order to maintain the impacts of human actions at a reasonable distance from the thresholds and thus preserve the self-regulating capabilities of the Earth. They are markers rather than definitive values, and the incessant scientific refinements make them more and more accurate. Identification and monitoring of planetary boundaries are based on data compiled for over forty years by consortia of global research on environmental change. The awareness of the existence of functional limits is part of the sustainable development path, since these limits inform us about the margins that our civilization still has or not. This information is being used as a tool to support decision-making processes and it is now one of the mandatory references of all United Nations agencies (Anctil and Diaz 2016, p. 64). The first two of the exceeded thresholds are the subject of multilateral agreements since the 90s.

The Nature's conception imbedded in the planetary boundaries approach is typical of our era. This representation is no longer part of the opposition between "ecocentrism" and "anthropocentrism", but reflects the ethical consequences of the Anthropocene for humanity: the obligation to find solutions to global problems generated by its intervention (Steffen et al. 2011). Instead of an Earth system considered as a mere provider of the socio-economic system, as it's represented in the so-called "anthropocentric" models, or as an envelope and support of life, as conceived by "ecocentric" models, planetary boundaries represent the most vulnerable side of our planet, both threatened and dependent on human actions. Humanity now realizes that "it depends on us that everything does not depend solely on us" (Serres 2014).

2.3 Social Floor

Adding a "social floor" to Rockstrom's "environmental ceiling", Kate Raworth, relied on the planetary boundaries approach to build her "donut" theory (Raworth 2012). She then delimited more precisely the safe and just space for humanity prosperity, representing the inalienable social gains to be guaranteed for equitable development.

As reminded before, human needs are one of the two central elements of the concept of sustainable development. Indeed, the WCED definition of sustainable development imposes the responsibility towards future generations as a condition to meet the needs of the present. This position echoes a consensus already present in the Stockholm Declaration (1972) which stated that concern for future generations should be an objective of humanity. In order to clarify the purpose of this responsibility, the WCED report drew on notions of needs and limits, which were at the heart of the polemics between the South and the North in the 80s. Indeed, to reconcile the concerns of inequality, both within and between countries, the WCED retained the principle of "inner limits" to sustainable development, which means to ensure the satisfaction of basic needs of all. Therefore, when it comes to reconcile development and environment, criteria that should guide the choice are the meeting of the needs of the poorest without exceeding the limits of resources and ecosystems (Anctil and Diaz 2016, p. 35).

Raworths's approach thus completes and updates the notion of sustainable development by identifying eleven essential needs to be guaranteed for all. Inspired by existing declarations and conventions on human rights, and based on global socio-economic statistics, she affirms that basic needs are income, food, education, health, gender equality, water, energy, jobs, social equity, resilience and voice. These needs are, for the most part, covered by several of the Sustainable Development Goals.

2.4 Sustainable Development Goals

Both Rockström and Raworth's approaches influenced the debates of the United Nations conference on sustainable development, Rio + 20 in 2012. These discussions led to the adoption in 2015 of the 17 Sustainable Development Goals (SDGs) by the United Nations General Assembly as part of its 2030 Agenda for Sustainable Development.[3] Building on the lessons learned from the Millennium Development Goals, this new framework must apply, if it wants to have the desired impact, to all countries, to all scales of intervention and by all actors and stakeholders.

Despite the broad consensus and the robustness of the scientific knowledge leading to SDGs adoption, they are still not sufficiently known beyond the domain of multilateral agencies, development cooperation and environmental sciences, and even less in francophone circles.

[3] https://www.un.org/sustainabledevelopment/.

Fig. 3 Conceptual scheme of the EDS integrated approach

For this reason, we have found the relevance of using a simplified representation to communicate the complexity of this new common challenge. In order to facilitate the diffusion and appropriation of this three approaches, we conceived a conceptual diagram to present them in an integrated way: the conceptual scheme of EDS-IA (Fig. 3). At the center of the scheme, the "ideation engine" contains the notion of scale, essential in the operationalization of sustainable development. Around, a donut circumscribed internally by the "social floor" and externally by the "environmental ceiling", represents the 17 SDGs. This graphic is used in training and research activities to analyze existing initiatives and imagine new ones by mobilizing all the information contained in each portion of the wheel in an integrated way.

3 Methodological Approach: Participatory Action-Creation

The conceptual scheme graphically represents the complex links between all the systems concerned by the issues of sustainability in the new context of the Anthropocene. This common starting base facilitates exchanges and collaboration among stakeholders.

The EDS-IA brings stakeholders together around a common analysis object. This object of study becomes a pretext for dialogue around a tangible problem of development requiring the competencies of all disciplines and the contribution of all types of knowledge. An analysis conducted since 2012 at *Université Laval* has identified more than 365 courses in all campus programs, all cycles combined, that contribute to the development of Key Competencies for Sustainability (KCS) (Richard et al. 2017). According to Wiek (2015), the project-based or case-study approach ensures the best conditions for acquiring the KCS and achieving a true interdisciplinary work. Based on this solution oriented approach, EDS-IA was designed for EDS activities that serve as integrative extracurricular trainings targeting the entire university community and students from all programs.

The integrated EDS-IA was designed first to mobilize researchers, teachers and students. However, by its very nature which is anchored in a specific environment or object, it calls for the intervention of professionals, citizens, entrepreneurs, governmental organizations from all sectors and scales of action as well as representatives of civil society organizations. Is thus a tool to facilitate dialogue between stakeholders, from different disciplines and sectors, around a given development challenge. This multi-stakeholder aspect characterizes the "living laboratory" dimension of this approach (UMVELT 2014). This dimension is part of the continuous improvement process that *Université Laval* has been driving since 2010 in its sustainable development performance guided by STARS certification criteria, managed by the Association for the Advancement of Sustainability in Higher Education (AASHE). Inspired by the R&D community, AASHE encourages universities to use their infrastructure to create environments facilitating multidisciplinary learning and applied research to promote sustainable development on their campuses in what it calls "campus as living laboratories" (AASHE 2017). EDS-IA contributes to *Université Laval*'s goal of improving the campus experience while promoting its outreach and positive impact on the surrounding community.

Since 2016, EDS has identified an object of study each year around which it invites all stakeholders and communities to mobilize to find new solutions and improve existing ones. For each object of study, the EDS-IA forecasts the realization of three sequential and additive stages: diagnosis, mobilization and ideation. The results of each step feed next one. Activities of each step can be adapted according to the studied object and to the concerned stakeholders.

3.1 Diagnosis

This first step aims to facilitate the appropriation of sustainable development issues and encourages the commitment of stakeholders, by answering the question: *What does sustainable development mean in my living environment*?

Participants are invited to carry out a participatory diagnosis on the studied object. The exercise begins with an appropriation of the different elements of the conceptual scheme. Participants are asked to identify the complex interactions between the different SDGs and the state of disruption or respect of environmental and social boundaries. The findings shared by the group are represented on the diagram.

This exercise allows to realize that, although the targets of some SDGs are fully compatible and even offer a multiplier effect, others may be incompatible. Consequently, this tension force the identification of innovative solutions to solve problems related to governance, development or the environment. This step can lead to the prioritization of SDG in the studied object and to identification of some possible solutions that can be further developed and elaborated in the following steps.

3.2 Mobilization

This second step mobilizes the knowledge and the actors that can contribute to the identification of new initiatives and solutions. The question that guides this step is: *What new contributions can I (each participant) make to existing initiatives and to the proposals from other participants*?

Based on the conclusions of the diagnosis, the scientific knowledge relevant to the studied object is presented and discussed in the form of workshops and plenary sessions at a symposium, forum or similar outreach activity. The different perspectives and knowledge brought by researchers, students and local actors are thus confronted around the studied object in order to bring out new hypotheses of interdisciplinary research and collaboration with society.

Knowledge mobilization is at the heart of the process in every activity. It is by sharing their knowledge about the state of the analyzed object that participants can converge to sound diagnosis. They can also identify the need for new knowledge to formulate solutions. Mobilization challenges the ‘owners’ of the specialized knowledge or academia to better communicate, develop and expand it in collaboration with society. This step also implies the effort of establishing a strategy to identify, reach and engage all stakeholders as early as possible in the process.

3.3 Ideation

Based on the results of the diagnosis and the knowledge mobilization from all stakeholders, participants at this step propose new solutions to the problems identified for the studied object. This prospective step forces the contextualization and the appropriation of knowledge by all the actors in an intense creative activity of short duration. The proposed solutions illustrate the benefits of an integrated and interdisciplinary approach to development.

4 EDS-IA Results and Implementation

4.1 Year 1: 2016–2017—Université Laval, Québec, Canada

Université Laval in Québec city is one of Canada's top research universities and global leader in numerous cutting-edge disciplines. Recognized internationally for having reached the first place in Canada according to the STARS-gold level accreditation granted by the AASHE association, *Université Laval* offered an excellent opportunity to test the EDS-IA. Indeed, after ten years of internal work on sustainable development, many initiatives had been undertaken and several stakeholders had already integrate sustainable development principles and indicators into their activities. The challenge then was to think about how to improve existing achievements and to plan new and more effective actions.

During the academic year 2016–2017, the three stages of the EDS-IA (diagnosis, mobilization and ideation, see Fig. 4) were respectively covered by the three flagship activities of the *Institut EDS*: Fall University, Annual Symposium in Spring and the Summer School. The first activity, the 2016 Fall University entitled "The campus of Laval University in the light of Sustainable Development Goals", took place on November 3th and 4th. »It was organized by the EDS Institute in collaboration with the Chair in International Development and the Executive Vice-President of the university, who was responsible for the sustainable development strategy at Laval University since 2008. This activity put together thirty graduate students from different disciplines along with members of the university staff, public officials and professionals, to share their knowledge and skills and to formulate new ideas to better address SDGs on the campus.

The groups started by the appropriation of the elements of the graphic by identifying links in existing activities. The event concluded by formulating proposals to improve student residences, encourage the use of active and collective transportation, and create a "nourishing campus" (Fig. 5). The information gathered and the contacts made for the organization of this first event made it possible to identify the necessary elements to carry out a diagnosis of the campus that was completed during the following months.

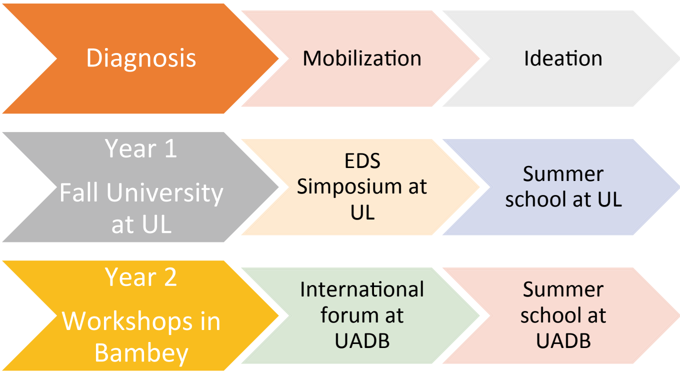

Fig. 4 Workflow of the three steps of the EDS-IA during the two first years

Fig. 5 Appropriation of the conceptual diagram during the diagnosis in 2016

The second step was carried at the EDS symposium in the spring 2017. Researchers from different disciplines presented researches conducted on *Université Laval*'s campus on the use of energy, night lighting and the reuse of waste among others subjects. Additionally, representatives from three Quebec universities explained their approaches and strategies for the integration of sustainable development in their respective campuses. Finally, the question of how to transform the campus into a "living laboratory" was discussed in a workshop.

The cycle of the first year of the EDS-IA implementation culminated in the completion of a three-day summer school in August 2017 during which about fifty participants proposed projects to transform the campus into a "living laboratory". This last event of the cycle focused on ideation, and built on the results of the two previous steps. During the first day of the summer school, the participants traveled the campus to meet with representatives of administration and services units who inform them on the challenges of the existing services (energy, housing, catering, transport, etc.). Such collaboration with the staff and authorities of the university was the result of the work done in the previous stages. At the end of the event, participant have formulate seven projects to transform the campus into a living laboratory by promoting the achievement of the SDGs for its users (Fig. 6).

Fig. 6 Summer school "Inhabiting a Nordic campus: let's imagine our future in a living laboratory"

4.2 Year 2: 2017–2018—Université Alioune Diop de Bambey, Sénégal

In February 2017, *Institut EDS* received a postdoctoral fellow from *Université Alione Diop de Bambey* (UADB) that realized his postdoctoral project on the adaptation of EDS-IA to his university. In July 2017, he started the process in Bambey with the organization of two workshops. The first workshop brought together students, staff members and teachers at the UADB and residents of the municipality of Bambey attended the second. Using the conceptual scheme, participants collectively identified the priority SDGs for the university and for the municipality and imagined possible solutions (Diop and Mbengue 2017).

The results obtained during these two workshops showed the relevance of transferring the EDS-IA in an international context. Despite the great differences between the realities of the two universities, both have similar needs in terms of knowledge of the SDGs and collaboration between disciplines and stakeholders from different backgrounds. According to these results, it was decided to continue the steps of the process and to complete the cycle with a forum and a summer school that were held in June 2018.

For those activities, eleven students from three cycles and several disciplines of *Université Laval* joined ten students of the UADB program of sustainable development and organized five teams. Each team worked on one of the five SDGs prioritized for the commune (2, 3, 6, 7, 8). A sixth SDG (11: sustainable cities) was chosen to integrate the results of the other five SDG. The five teams continued the diagnosis initiated with workshops in 2017, by analyzing existing reports on the status of the SDGs in Senegal and in Bambey. Once in the field, the teams realized a visit of the commune and met local government officials, community organizations, commune service managers, as well as residents to complete the diagnosis of the five SDGs.

The summer school was held in the framework of the International Forum on the SDGs carried out by UADB on June 19 th and 20 th. With the nearly 30 speakers and about 100 participants, the forum served as knowledge mobilization stage.

Finally, about a hundred participants from speakers and audience of the forum and representatives from local organizations joined the student teams to achieve the ideation step during a one-day workshop at the end of the forum, the living

Fig. 7 Summer school "Make Bambey a living laboratory for the SDG"

laboratory held on June 21. The five extended teams formulated ideas for improving the achievement of the five SDGs and integrating them into SDG 11. The integration team formulated the proposal to develop a plan, which would be supported by the partnership between UADB and the City of Bambey. This plan, that would contain the projects proposed by the other teams, was named *Cingeen Bokk* (in Wolof) which means "Everyone is part of it". The plan would contribute to realize the vision adopted in the declaration emitted by the participants of the forum, that of "making Bambey the first ecological city of the Sahel" (Fig. 7).

5 Contribution and Perspectives

5.1 Universities as Living Laboratories for SDG

The first two years of implementation served to test the basic postulates and the relevance of EDS-IA in universities. It has been found that universities have great potential to integrate the SDGs into all their fields of action, whether in research and training as primary missions, but also through their operations and increasingly through the links with the communities and territories where they are located. Matching these four pillars of university action to the SDG can position universities as major actors in transforming global society towards a more sustainable model. In turn, this positioning will promote the relevance of the research conducted and the attractiveness of the studies offered by universities (SDSN 2017).

This double benefit will be further strengthened as the four intervention components are mutually fed and reinforced by a living laboratory approach. Thus, listening to the needs and concerns of the community, reinterpreted in the light of the social vision validated globally by the SDGs, makes it possible to bring out new responses in interventions on university campuses. These new interventions, designed and implemented in collaboration with researchers, students and all types of stakeholders, help to identify the knowledge to be mobilized and the new research questions to be developed. Finally, this whole process is a privileged means of learning and for the development of KCS and all skills needed for the transformation of society.

5.2 Participatory and Interdisciplinary Action-Creation

Finding solutions to achieve sustainable development requires the mobilization of all disciplines. Intense collaboration between sciences is needed to understand interactions between social and natural systems and to find ways to harmonize them. The ability to work in an interdisciplinary way is a skill that is increasingly required for researchers and professionals. However, most university curricula remain disciplinary based and do not offer many opportunities to develop interdisciplinary skills.

The first condition for interdisciplinarity is communication. The EDS-IA mobilizes participation techniques that focus on listening and respect for the spoken word and collective decision-making. It encourages the sharing of all types of knowledge (practical, scientific or traditional), which implies that participants should make the effort to communicate their knowledge in an accessible and precise language.

The identification and choice of projects is a collective creation exercise that aims to promote action. Inspired by the intense creative exercises practiced by conceptual disciplines such as "architectural charrettes", this approach aims to maximize the power of mobilization or generation of knowledge to reach a collectively designed goal.

5.3 A Qualitative Approach to Complete Quantitative Ones

An important aspect of the SDGs is its quantitative nature, expressed in its targets and indicators as a global monitoring effort with a common frame of reference. These data are the basis of the work of many international research teams that are deeply analyzing interactions between SDGs and their targets, as well as the impacts of these interactions for policy research and decision-making (Nilsson et al. 2016; Dodds and Bartam 2016).

These analytical approaches, based on granular data, make it possible to formulate models of interaction between SDGs to foresee the possible effects of sustainable decisions. Their results can be very useful tools to evaluate policies and to choose between several possible actions in planning exercises. However, the information generated with this kind of approaches may be difficult for a broad population to access, which does not facilitate participatory processes.

Unlike analytical and quantitative approaches, EDS-IA builds on the SDGs as a comprehensive framework for action to integrate the three pillars of sustainable development. Moreover, by adding the concepts of environmental limits and social floor, it forces to take into account global scientific and statistic data. Based on a qualitative approach and on the knowledge of the participants, this approach allows both novices and experts to realize the contribution of their own actions to a global process and to identify ways to improve existing initiatives to make them more meaningful and effective.

5.4 Governance as an Integrating Element

The two years of implementation of the approach have shown that effective collaboration of stakeholders in sustainable development, even in the case of private actors or in the academic community, requires the presence of effective institutions with clear guidance and relevant and robust coordination and monitoring mechanisms. In both universities experiences, proposals that emerged have put governance at the core.

Thus, at *Université Laval*, the proposal of one of the teams specifically concerned the creation of a vice-rectorate devoted specifically to sustainable development to ensure the realization of the proposed projects. At UADB, the methodology planned to articulate all the proposals by choosing SDG 11 (sustainable cities) as an integrating element. However, in the course of the exchanges, the integration tool proposed by the participants was a participatory development plan. This leads to add SDGs 16 and 17 to highlight the importance of effective institutions and partnerships.

In both experiences, the process proved to be particularly relevant to inform and raise awareness in a large number of participants who, despite their interest and commitment to sustainable development, were not aware of the existence of the SDGs or did not feel concerned by this framework. This bottom-up exercise oriented to civil society is complementary to other existing capacity-building tools, must of which have public administrations as the primary targets.

6 Conclusions

Although the growing scientific understanding of environmental challenges and the multiplication of individual actions to redress the unsustainable trends, humanity still lag behind in its quest for sustainable development. The SDGs provide a system of key indicators that can be used as a dashboard of public decisions. However, the link between individual actions and global impacts can only be achieved by improving the effectiveness of collective action.

Knowledge sharing and collaborations between actors in all fields and sectors are major drivers of change in society. Collective creative exercises promote teamwork skills and the emergence of transformative initiatives. EDS-IA combines these elements to offer meaningful and inspiring meeting opportunities that can serve as a trigger for a process of collective transformation towards a more sustainable society.

Universities can play an important role as drivers for the implementation of the SDGs. Approaches considering universities as “living laboratories” as the EDS-IA does, are proving to be effective tools for concrete and integrated intervention design for sustainability.

The first two years of implementation of the EDS-IA allowed to identify the relevance of this approach to facilitate linking stakeholders and disciplines and to encourage collaborations and action. It should be noted, however, that the ideas that emerge during the co-creation processes achieved with EDS-IA, must be transformed into more elaborate projects and then into concrete actions. These stages of development and implementation are not part of the process for the moment, which does not allow to measure concrete impacts.

With regard to key competencies on sustainable development, as literature shows for all kind of competencies in education, it is difficult to determine to what extent the activities carried out under the EDS-IA contribute to developing these skills. Especially since the activities organized by *Institut EDS* are still uncredited and are not part of the regular study programs.

However, the collaborations with professionals and government authorities established over these two years allow us to remain optimistic about the viability and feasibility of ideas that emerged during the process. We already know that at least one of the projects proposed at the Bambey Summer School has received support from the UADB Entrepreneurship Project Support Unit.

On the Quebec side, the experience drawn attention from observers from different backgrounds. Thus, the institute is currently exploring the possibility of transferring the approach to schools in the province. In addition, the third year of the process (2018–2019) has now begun in collaboration with the City of Quebec and many partners from the provincial and federal governments. It will focus on conservation and enhancement of biodiversity as a driver for the promotion and implementation of all SDGs in a strategic area of the city.

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Part II
Education for Sustainable Development

Auditing the University: Promoting Business Education for Sustainability Through Audit-Based Learning

Kay Emblen-Perry

Abstract Efforts to improve university-wide sustainability generally include sustainability learning, teaching, assessment, and campus sustainability activities; traditionally discrete activities facilitated separately by academics and estates' management staff. In order to incorporate a local context into the University of Worcester Business School's education for sustainability and improve university-wide sustainability performance, these two strands have been combined to create a constructivist, learner-centred business sustainability module based on sustainability audits of the University. Auditing the University provides practical, active audit-based learning to deliver students' evolving preferences for experiential, collaborative learning and employers' demands for employment ready graduates. The sustainability audit undertaken uses real-life business processes to develop students' sustainability knowledge and skills that are vital to promote sustainable business futures and softer employment skills such as negotiation, collaboration and influencing, which are essential for future career success. This paper presents a case study analysis of a Level 5 undergraduate business sustainabiltiy module that utilises audit-based learning and explores opportunities and challenges associated with delivering it. It reports the findings of a study into students' experiences of audit-based learning in the module, which operates as a 'living lab', and explores its ability to promote innovative learning, teaching and assessment in education for sustainability. The paper also utilises the Framework for 21st Century Learning to explore audit-based learning's ability to develop knowledge and skills appropriate for 21st Century businesses. Research findings are synthesised to capture and share this innovative approach to learning, teaching and assessment of business sustainability and offer insights to developers of interactive, experiential sustainability learning, teaching and assessment tools.

Keywords Audit-based learning · Sustainability audit · Learning, teaching and assessment · Business sustainability · Education for sustainability

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1 Introduction

Over the last 20 years governments, organisations and the public have increasingly recognised that Higher Education (HE) should provide key players in shaping a sustainable future (Disterheft et al. 2015; Figuero and Raufflett 2015). It has long been held that universities' most valuable contribution to support this future proofing is to develop students with appropriate knowledge and skills (Chalkley 2006; Rieckmann 2011; Quality Assurance Agency for Higher Education 2014). This can develop sustainability advocacy and feed forward to graduates' future workplaces, thus making a difference from within and contributing to the delivery of Sustainable Development Goals (SDG) 4 and 12. Universities form the link between knowledge generation and knowledge transfer by educating future business managers and decision makers (UNESCO 2011) so such that universities are increasingly focusing on developing graduates who are employable (Leal Filho et al. 2016).

Whilst the potential for HE to contribute to addressing global sustainability challenges through education, learning and teaching and research is well recognised (Rieckmann 2011; Sterling et al. 2013; HEFCE 2013; Higher Education Academy 2015) Education for Sustainability (EfS) has lagged behind the sustainability interests of business and change agents (Benn and Dunphy 2009). A sustainability skills gap now exists (Edie 2015; Laurinkari and Tarvainen 2017) with business management curricula not adequately preparing students to deal with sustainability issues (Waddock 2007). Sadler (2016) considers this has also resulted in a gap in students' higher order cognitive skills. To overcome these gaps, practical tools are required to equip students with the sustainability business knowledge and skills demanded by organisations and provide employment-ready graduates.

However, educators fail to agree on how to integrate sustainability into management education or where it should fit into the curriculum (Figuero and Raufflett 2015). The author believes that waiting for a consensus before introducing business sustainability learning, teaching and assessment (LTA) into EfS will not adequately equip current University of Worcester Business School students with the appropriate knowledge and skills to act as change agents in the quest for sustainable business futures. Consequently, an innovative approach to EfS has been introduced to engage business management students in sustainability learning and the development of employment skills: Auditing the university.

This paper presents a practical example of a module designed to engage second year business management students in EfS through audit-based learning (ABL). It introduces the innovative Business Sustainability module in which the LTA strategy focuses on a campus sustainability audit and explores the value of ABL for delivering effective, successful EfS. Students' reflections on participating in audit-based LTA are examined and the research findings mapped against the Framework for 21st Century Learning (Partnership for 21st Century Skills 2007) to establish the ability of ABL to develop students' sustainability knowledge and skills and employment skills that are required to develop sustainability advocates, promote sustainable futures and deliver employment ready graduates.

The paper adds to pedagogic discourse of EfS and offers experience based guidance to the other educators in the sustainability community seeking innovative active learning approaches to EfS. The experiences and learning presented add knowledge of practical LTA tools and techniques that can develop students' knowledge and skills whilst producing graduates with both sustainability and generic employment skills demanded by employers.

2 Sustainability in Business Education

In the last two decades sustainability has been gaining prominence in HE (Figuero and Raufflet 2015) with the potential for universities to address sustainability issues through research, learning and teaching well recognised (HEFCE 2013; Higher Education Academy 2015). Not only are Business Schools obliged to prepare students to make responsible and ethical management decisions that meet the needs of future business leaders (Stough et al. 2018) and deliver society's demands for responsible businesses (Adomssent et al. 2014), they must also recognise their sustainability performance is a key factor in many students' choice of where to study (Nuwer 2014). However, against this focus on HE's role within sustainability, Sadler (2016) highlights the current international concern that a large proportion of graduates lack higher order cognitive skills such as proficiency in thinking, reasoning, synthesising, conceptualising, evaluating and communicating; key skills for the development of sustainable futures.

To address these skills gaps and demands for sustainable universities, business school educators are increasingly challenged to establish new learning cultures. These new learning cultures should initiate new ways of learning in a participative and reflexive process (Rieckmann 2011; Molthan-Hill 2014), which can empower students to transform the way they think and act (UNESCO 2017) whilst developing employment ready graduates with the specific and generic employment skills demanded by businesses (Docherty 2014). Students' success in this 21st Century learning environment requires innovative teaching approaches and support systems to engage them with appropriate knowledge and skills, and real world connections to make the learning relevant and engaging (Partnership for 21st Century Skills 2007). The audit-based learning explored here may deliver this innovative teaching approach and support system by promoting identification, integration and evaluation of the university's sustainability practices to construct a personal, evidence-based view of sustainability performance whilst delivering specific, general and transformative employment skills.

3 Education for Sustainability

The main role of EfS within HE is to transform students by enhancing their knowledge and skills (Harvey 2000) and promoting effective learning outcomes of values, attitudes and behaviours (Shephard 2007) to empower them to assume responsibility for creating a sustainable future (UNESCO 2002). Universities' most constructive contribution to achieving this sustainable future is to provide innovative approaches to EfS in which students are equipped with appropriate knowledge and skills (Rieckmann 2011; Chalkley 2006) and engage with business to solve real-life problems for both businesses and society (Molthan-Hill 2014).

The demand for graduates with knowledge of both sustainability and business that grew up a decade ago is continuing to grow (Stubbs 2011) such that students and graduate employers now expect academics to promote employment skills within learning, teaching and assessment (Pegg et al. 2012). Despite this, a sustainability skills gap still exists and in many cases sustainability knowledge of the graduates does not meet business needs (Laurinkari and Tarvainen 2017).

To promote sustainability and business skills to prepare students for the workplace and ensure they gain appropriate knowledge and skills to produce sustainable futures, HE is undergoing transformation in sustainability teaching. This, coupled with the marketised culture of 21st Century HE, is reshaping EfS and demanding educators introduce innovative practices into LTA (HEFCE 2013; Higher Education Academy 2015).

In this marketised environment of HE, EfS can be seen to have three main actors: students, educators and employers. These actors have individual expectations of outcomes: Students expect good grades and employment skills delivered through participatory learner interactions (Conole and Alevizou 2010) rather than traditional instructivist approaches such as slide based lectures; Educators hope for student engagement, sustainability literacy and values for advocacy; Employers demand employment-ready graduates who possess appropriate sustainability knowledge and employment skills (Drayson 2014). An element of overlap can be seen between students' and employers' expectations of employment skills and educators' and employers' hope for sustainability knowledge which HE are expected to deliver. In addition, although not a main consumer of HE, the Government's strategic hopes and expectations to increase the skills base of the UK and enhance the employability of graduates (Harvey 2000) also directly influence the three main consumers' behaviours.

These actors' expectations, hopes and demands have arisen in the marketised culture of HE so that a complex EfS learning environment has emerged requiring different approaches to deliver academic content and help students acquire skills required for the 21st Century workplace such as collaboration, critical thinking and communication (Buck Institute for Education 2017). Business Management education must therefore prepare students to respond to the environmental, social and ethical dilemmas that increasingly confront organisations (Navarro 2008) in a way that is relevant and in contexts they find meaningful (Crossthwaite et al. 2006).

Providing a learning environment that supports and challenges learners' thinking can enable students to become effective workers (Savery and Duffy 1995) and support the development of generic and transferable employability skills (Crossthwaite et al. 2006). This environment should be active, experiential, participative and collaborative to obtain the best student outcomes (Dewey 1916). Rieckmann (2011) considers this environment should also have a problem orientation and link formal and informal learning to facilitate development of key competencies that are needed to deal with unsustainable development. Wiek et al. (2014) expand this perspective and argue the LTA approach should include real-world settings so that students are educated in relevant environments and able to develop workable solutions to promote sustainable futures.

However, a broad range of functional barriers may affect the implementation of sustainability curricula and prevent the adoption of innovative LTA approaches to EfS (Lambrechts and Ceulemans 2013). Consequently, many researchers examining the best ways to deliver EfS consider educators need to radically rethink management education to encourage students to think in new ways (Figuero and Raufflet 2015; UNESCO 2017). The author believes that without change, educators will not meet the growing expectation that universities should contribute to a sustainable society through education, research and operations (Sterling et al. 2013; HEFCE 2013; Higher Education Academy 2015; United Nations 2017), therefore audit-based learning has been adopted as an innovative LTA approach to business sustainability.

4 Audit-Based Learning

A sustainability audit is a methodical examination of organisational procedures and practices determining or influencing environmental, social or economic impacts. It is a voluntary, essential management procedure that allows an organisation to detect problems before they affect operations (Hillary 2004), provide a benchmark from where to measure subsequent change (Clark and Whitelegg 1998) and develop a systematic approach to improving sustainability performance whilst improving economic performance (Viegas et al. 2013). Auditing is therefore an important employment skill for graduates to feed forward into their workplaces to contribute to sustainable futures.

The use of Environmental Management Systems and certification standards such as ISO14001, EMAS or EcoCampus as a method of improving universities' sustainability performance is well researched e.g. Disterheft et al. (2012); with environmental audits generally presented as extracurricular learning tools for students studying in all faculties. However, there is some recognition of the opportunity to utilise a campus sustainability audit as a learning and teaching tool embedded within business curricula (e.g. Alshuwaikhat and Abubakar 2008; Lambrects and Ceulemans 2013) but less proposing a sustainability audit for an assessment (e.g. Bardati 2006). The limited literature does agree, however, that audits can offer a valuable approach to EfS as they promote active learning amongst participants, which provides an opportunity to transform sustainability thinking (Bardati 2006; Ferreira et al. 2006).

The authors' experience of audits as an ISO Auditor and Auditor Trainer suggests the process of undertaking a sustainability audit of the campus and reflecting on the findings to recommend strategic improvements can provide an innovative approach to business sustainability for business management students. This LTA approach delivers students' preferences for active learning (Oblinger and Oblinger 2005) in a real world setting (Wiek et al. 2014) that can engage students in sustainability knowledge and skills and softer employment skills demanded by businesses (Docherty 2014).

The author defines ABL as 'learning achieved through preparing and undertaking an audit and reflecting on its outcomes'. The audit project is both an outcome and a process of learning (Corcoran and Wals 2004) through which students recognise and take ownership of their learning needs, which Savery and Duffy (1995) recognise as a critical component of learning. The sustainability audit also reflects the complexity of the environment student will progress into after graduation.

ABL combines three learning styles that can generate positive learning outcomes and stimulate students to be active learners rather than simply consumers of knowledge (Juarez-Najera et al. 2006). Firstly, 'learning by doing', which can generate student engagement (Dewey 1916; Drayson 2014); the most important issue currently facing the HE sector (Leach 2016). Secondly, project-based learning, which can equip students with softer employment skills such as collaboration, negotiation and influencing and transferable academic skills such as enquiry, problem solving and critical analysis. Thirdly, active learning in a real world setting which can help students find their place in the world by doing what they learn (Bardati 2006). Crosthwaite et al. (2006) consider the development of generic and transferable employability skills is more likely when students engage with realistic and relevant experiences in contexts that they find meaningful.

Within ABL, students are exposed to wider issues, which they explore in a real world context, than would be encountered through passive learning in the classroom. Knowledge gained in this environment is retained for longer than knowledge gained in passive learning experiences (Gardiner and D'Andrea 1998). Beckett and Murray (2000) argue that audits offer valuable double loop learning as they expose learners to a variety of possible future scenarios through a critical evaluation of their own decisions.

As an approach to students' preferred active, project-based learning (Oblinger and Oblinger 2005; Wiek et al. 2014), ABL can support student engagement, develop employment skills demanded by employers and provide students with the opportunity to generate sustainability knowledge and skills and apply them to real life, which stimulates self-directed deeper learning (Moalosi et al. 2012) and promotes advocacy for sustainable futures.

5 Audit-Based Learning in Practice

The Business Sustainability module's learning environment presented in this paper has been constructed to deliver the expectations, hopes and demands of the three key actors within EfS. It provides a practical introduction to business sustainability through a competence-orientated approach to EfS, which aligns theory and practice using the module as a 'living lab' and the university as a real world learning environment. Developing competence through ABL can develop capability to collect, collate, analyse and utilise the available information that Vare and Scott (2007) argue can develop learners' knowledge and skills to make sustainable choices in an environment of inherent complexity and future uncertainty. The author aims to deliver this by using real world business tools (the sustainability audit framework and auditing processes) and practical, collaborative activities to achieve this. Incorporating an audit as the assignment and focus of in-class activities provides an authentic task in a supportive but challenging environment that Savery and Duffy (1995) argue is required for learners to accept the learning relevance. This challenging task and environment also supports the development of higher order cognitive skills that Sadler (2016) argues are missing in many current graduates.

The first six of the of the module's twelve, weekly 3-hour taught sessions focus on specific business sustainability topics including, but not limited to, as environmental management, social responsibility and economic responsibility to engage students in the basic sustainability knowledge appropriate for second year undergraduates. The next 3 taught sessions focus on embedding this knowledge and exploring the effect sustainable and unsustainable behaviours can have on businesses, including their responses to internal and external pressures from, and impacts on, stakeholders. The module concludes with consideration of potential solutions to the sustainable and unsustainable issues and implementation strategies. Training for auditing is provided throughout the module in formal and informal training sessions with practical, participatory in-class activities designed to support formal audit training.

In place of extensive slide based lectures feeding knowledge to the students, which is likely to promote just-in-time learning and short-term knowledge retention (Emblen-Perry et al. 2017), the author introduces practical activities such as treasure hunts, sustainability communication filmmaking, quizzes, the Environmental Impact Assessment Game etc. that engage students in individual and peer-to-peer learning through discovery. These activities are designed for students to explore the University's sustainability practices in a fun and engaging learning environment and develop an understanding of real world practices and behaviours.

These activities provide students with examples of sustainable and unsustainable business practice, process and strategy within the student's immediate and personally relevant environment; the university. In-class working with the university's business processes offers two advantages; it exposes students to real world sustainability processes and enables ongoing face-to-face support and formative feedback that current students expect (Ramsden 2013). It also provides opportunities for the author to encourage students to collect information for the assessed audit on a phased basis rather than leaving it to the last minute. This scaffolding aims to promote students' self-perceived competence in the audit process as it can significantly motivate engagement (Fazey and Fazey 2001).

Post-activity debriefings are provided to connect the students' experience of sustainability in practice to sustainability theory, good practice and wider corporate and societal values. This aims to embed knowledge, encourage students to develop an individual and collective sense of responsibility that Burgess (2006) and Ellison and Wu (2008) consider able to motivate learning for good practice; a fundamental requirement of EfS. These opportunities for reflection on what has been learned and on the learning activities can encourage peer-to-peer learning and develop independence (Savery and Duffy 1995) and transferable employment skills and knowledge such as enquiry, problem solving and critical analysis.

The module assignment consists of three elements: firstly an audit of the university's sustainability performance; secondly, an overall analysis of the audit findings and lastly, evidence-based recommendations to improve the students' top three issues of concern. The students have flexibility within this assignment, as, although they are expected to show a detailed and holistic understanding of sustainability and ability to apply it at a business level, there are no right or wrong answers. This challenges thinking and encourages them to take ownership of their processes used to research and develop improvements; a LTA approach that Savery and Duffy (1995) suggest encourages learners to recognise what knowledge they need to complete the task. It also engages students in learning for generative sustainability as the answer to the assignment cannot be downloaded wholesale from the internet.

The audit is completed on an audit template adapted from documentation the author utilised as an ISO14001 auditor. Audit evidence is collected from a site inspection, analysis of sustainability documentation and practices and initiatives published on the university's sustainability web pages and audit meetings with campus practitioners. This qualitative and quantitative data is included as evidence of performance in the audit template and evaluation of overall performance. These audit and assignment processes engage students in analysis and presentation of evidence in a professional, factual manner, which offers good preparation for their Level 6 independent study project.

Students rate their perception of the sustainability performance of the university against a number of criteria provided: Sustainability Policy, Human Resources for Sustainability, Auditing and Management Systems, Ethical Investment, Carbon Management and Reduction, Workers' Rights, Sustainable Food, Staff and Student Engagement, Sustainability Impacts, Energy Use and Sources and Waste and Recycling. Their evaluation and therefore their rating is based on the evidence collected during their independent research, campus audit and taught sessions.

Once students have completed their audit they are required to analyse their findings to provide an overall assessment of the university's performance and select three key issues (positive or negative) that they believe could be improved or enhanced. The choice of issues must be fully rationalised with academic literature. Students then carry these three issues forward and recommend evidence-based actions to address them. This exposes to an environment of double loop learning that allows the detection of problems and creation of potential solutions that prevent problems in the future (Argyris 1982; Beckett and Murray 2000).

To support the assignment and develop employment skills the author engages students in audit skills: questioning, listening and looking. Students are encouraged to undertake a site inspection of the campus to discover examples of sustainability issues and good practice and explore the university's sustainability website, which can provide evidence for their audit. This exploration engages students in the looking skills required for a successful audit. The author suggests they undertake this in groups and share findings to use their resource efficiently, promote a comfortable learning environment and gain experience of group work and peer-to-peer learning and the opportunity to practice their softer employment skills of collaboration, negotiating and influencing.

Audit meetings are held with members of the university's operational departments including the Sustainability Director and representatives from Procurement, Operations, Catering, etc. during taught sessions. These sessions give the students the opportunity to test their audit skills of questioning on the university's sustainability practitioners, discuss their site inspection findings with those implementing sustainable and unsustainable practices and ask for more information to support their audit. This mirrors the audit meetings held during a real-world sustainability audit such as for ISO14001 certification and gives students further opportunity to practice their softer employment skills. Audit meetings also provide students time and space to reflect on their knowledge and skills that are vital for sustainability advocacy and future employment.

The use of ABL for the business sustainability module presented here supports the University of Worcester Business School's learning, teaching and student experience approach that promotes personal contact between students and staff through small classes, face-to-face support and extensive formative and summative feedback as well as integration of employment skills and personal development grounded in real world activity.

6 Design of the Study

Two mixed method questionnaires were distributed to 29-second year undergraduate students in the first and last lectures of the 12-lecture module. The first survey, Phase 1 of the research, was designed to gain an understanding of students' perceptions of their pre-module sustainability knowledge and skills, employment skills and audit experience and expectations of the audit assignment. The second survey, Phase 2 of the research, was undertaken in week 12 to capture students' perceptions of their post-module sustainability knowledge and skills and reflections on their audit experiences and development of employment skills. These timings were set to obtain a general pre and post module comparison to test ABL's ability to enhance sustainability knowledge and skills and to identify where and when formative feedback and additional support could be offered to enhance engagement with the audit process and the module. As student responses were anonymous no absolute comparisons can be offered, rather the findings reported indicate the impacts of ABL across the module cohort.

The surveys requested both quantitative and qualitative responses. Quantitative questions asked students to evaluate their sustainability knowledge, skills and experience against a four-point rating scale: No Knowledge, A Little Knowledge, Good Knowledge or Very Good Knowledge. The survey was short and simple to ensure it was accessible to all students; half of the class comprised international students for whom English was their second language. Four rating options were utilised to avoid participants merely adopting the central, neutral rating advocated by Moors (2008).

Qualitative extensions to the quantitative questions asked students to reflect on their audit experience and expectations of conducting an audit (Phase 1) and experience of conducting an audit, participating in in-class activities linked to the audit and development of sustainability knowledge and skills during the module (Phase 2). Students' responses were synthesised through an inventory of points into a segmentation of key points expressed following the approach recommended by Bertrand et al. (1992). To encourage voluntary participation and maintain appropriate levels of confidentiality for this research all responses were collected and analysed anonymously. The quantitative survey responses were collated and presented as general self-reported actions and experiences, using students' feedback to illustrate the research findings. The author recognises this study presents the self-reported results of a one-time, small study that does not offer generalised, independently validated responses. However, the findings may be of interest to educators considering the adoption of innovative LTA approaches and those seeking new learning cultures for EfS.

The framework for 21st Century Learning (Partnership for 21st Century Skills 2007) was used to test the ability of ABL to engage students in sustainability and employment knowledge, skills and experiences that can help prepare them respond to environmental, social and ethical dilemmas that they will confront in future workplaces. The qualitative research findings and the author's reflections were mapped against the framework's skills, knowledge and expertise criteria. These represent the necessary student outcomes for the 21st century learning; Learning and Innovation Skills, Information, Media and Technology Skills, Core Subjects and 21st Century Themes, and Life and Career Skill, and the support systems required for effective learning (Partnership for 21st Century Skills 2007). This framework allows evaluation of the process, performance, outcomes of ABL against the knowledge and skills required to evaluate a large quantity of information, solve problems creatively, work in teams and communicate clearly in many media, which businesses require of graduates (Partnership for 21st Century Skills 2007).

7 Research Findings and Discussion

7.1 Development of Sustainability Knowledge

Students' reflections in the Phase 2 survey suggested they all gained knowledge of environmental, social and economic sustainability and global issues:

Students reported:

> I started with no knowledge and now I am quite good
>
> This module has helped me develop more sustainable thinking and develop ideas on ways we could act sustainably
>
> I feel I have gained a great amount of knowledge
>
> I learned by doing my assignment and through the module. It made me think more ethically and I came up with better solutions.
>
> I feel that I have gained some important insights into sustainable development

Students appear to have progressed up at least one rating scale with the majority perceiving they ended the module with good or very good knowledge. Whilst this is self-reported, it indicates that ABL can provide sufficient learning for students to recognise their own knowledge and skill development.

The Phase 1 survey suggests students have a lower awareness of social sustainability than environmental activities at the beginning of the module; 65% of students believed they possessed little knowledge and 24% no knowledge of social sustainability; only 11% of respondents perceived they had a good knowledge. In comparison, 50% of students reported good or very good knowledge of environmental sustainability. Phase 2 survey responses, however, suggest learning of social and environmental sustainability and had taken place with all of students believing they had developed good or very good knowledge within these two areas.

Students reported lower levels of economic sustainability knowledge growth. In the Phase 1 survey almost 60% of students possess little or no knowledge of economic sustainability. This reduced to 27% with little knowledge at the end of the module. However, whilst the students developed knowledge of economic sustainability this was not as great as for environmental or social sustainability. The author suggests this may result from the apparent lower focus that economic sustainability receives within the university's sustainability activities and their greater prior knowledge and ease with current environmental debates. Modification to the audit template and additional focus from the sustainability practitioners may presents an opportunity to raise the profile of economic sustainability within future module occurrences to obtain a balance of learning across all three areas of sustainability.

Phase 1 survey responses suggest students' initial knowledge of environmental activities appears to have come from their personal interest and undertaking extracurricular activities during their university career. Only 29% of students confirmed their knowledge came from previous Level 4 university studies. As sustainability is not taught at this level within Worcester University's Business School the author suggests this response is likely to have been made by Exchange Students within the module.

Only 6% of respondents reported gaining environmental sustainability knowledge from their studies at school or college. The author considers this is surprising as the UK HE sustainability community generally accepts that schools teach at least basic environmental awareness such as climate change and recycling. Perhaps there is a limited connection between environmental studies and the word ‘sustainability’ which needs to be addressed. Students’ reported their sustainability knowledge came from:

> I lived in “Greenhouse Floor” during my first year at university–a community within dormitory focusing on sustainability/green living
>
> Interest in outside sources such as the news and magazines such as the Economist
>
> Personal interest in environmental technology developments
>
> International student organisation activities
>
> Business Studies in secondary school
>
> Personal interests and work

Knowledge of globalisation issues increased throughout the module with students’ belief of having good or very good knowledge increasing from 48% to 91%. The author notes that 55% of students on Business Sustainability module were international Exchange Students from Scandinavia, India, South Korea, the Philippines, America and Bangladesh who brought different experiences of sustainability practice and LTA approaches from their home universities into the lectures. Having this range of international students in the class representing a range of cultures was valuable as it enabled discussion on global issues from a range of local perspectives. Students reported:

> This module has offered different perspectives regarding global issues than I had previously come across
>
> I have more knowledge about sustainability in the world
>
> I learned about different kinds of sustainability

The research findings suggest undertaking an audit can engage students in personal and university-wide sustainability actions and initiatives and markedly increase understanding of the university’s sustainability practices and policies: from 77% of students having little or no knowledge of sustainability practices within the university (Phase 1) to 82% having good or very good knowledge (Phase 2). Students reflected:

> I am now more aware of the sustainability work at the university
>
> Different initiatives that have been taken by the university on various aspects and my own personal research has helped me develop my knowledge.
>
> I did not know anything about sustainability. After this module, I learned a lot about my environment
>
> By doing my assignment in this module, it made me think more ethically and come up with better solutions

7.2 *Students' Expectations and Perceptions of Auditing*

The Phase 1 survey responses indicated no students had participated in or had knowledge of sustainability auditing prior to the module. Despite this, half the students had positive or very positive expectations about conducting an audit for their assignment and were looking forward to the module. Students reported their feelings towards conducting an audit:

> [I'm] excited but nervous
>
> Why not, can be great
>
> Excited
>
> Happy

However, varying levels of student concern in having to undertake an audit emerged in the Phase 1 survey: 13% of students reported feeling anxious and 25% not confident about their performance. A further 12% reported having no feelings about it. Students reported:

> I've never done an audit before so it seems a bit overwhelming
>
> Anxious as I'm not sure how to go about it, but confident I'll learn how.
>
> Slightly overwhelmed but confident I will feel better about it as the course progresses

A comparison of Phase 1 and Phase 2 survey responses suggest students' actual experiences of preparing and conducting an audit were generally better than initially expected; 90% of students reported feeling positive or very positive about the audit having participated in audit process training, undertaken some auditing and participated in in-class activities. Students suggested:

> I felt a bit worried in the beginning but now it feels OK!
>
> Great!
>
> Very good
>
> I am still in the process of completing my assignment but it's looking fairly good so far

Although a small proportion of students remained concerned about completing their audit, more than 80% considered they had sufficient knowledge to conduct a sustainability audit for their future employer. The author considers the support offered through formative feedback, audit training, in-class activities and discussions with sustainability practitioners has contributed to students overcoming their initial fear of the unknown, developing confidence and recognising their enhanced employment skills.

Students' feedback suggests peer-to peer learning, employment skills of communication, group work, critical analysis and collaboration are also generated through ABL. Students reported learning from:

> Talking a lot about environmental issues and doing group work with my friends, I learned a lot from them
>
> Games and working in groups

Going to the lectures and listening carefully

Students' survey responses also highlight ABL's ability to develop research skills such as data collection, information synthesis, management of work and project management. Students appear to feel this is a particularly valuable outcome of the module. Students reported:

The module greatly improved my research skills

It helped with self-direction due to large size of coursework

I have developed a more innovative way of thinking

The module allowed me a good opportunity to grow my research skills with various media formats.

This unsolicited recognition of ABL's value for developing academic skills suggests this LTA approach to EfS for business management students may encourage them to engage in new ways of learning that can empower them to transform the way they think and act and promote higher order cognitive skills. In addition, research findings suggest ABL is able to develop students' confidence, sustainability knowledge and skills, academic skills and employment skills.

7.3 ABL Value for 21st Century Learning Outputs

Mapping evidence from the survey responses and the authors' reflections of the process and outcomes of ABL against the 21st Learning Framework (Fig. 1) suggests that the ABL approach to LTA can provide appropriate skills, knowledge, expertise and support to enable students to be productive learners and successful in life, work and citizenship. These are the key objectives of 21st century learning (Partnership for 21st Century Skills 2007).

The research findings suggest ABL can contribute to the framework's four key 21st century students' outputs: learning and innovation skills, life and career skills, information, media and technology skills and core knowledge:

- Learning and innovation skills have been achieved through data collection, critical evaluation, problem solving and creative and innovative ways of thinking promoted from ABL. Students' development of research skills and new ways of thinking are also highlighted in the research findings.
- Life and career skills have been developed through the self-direction generated by the audit and associated in-class activities, engagement with project management skills, independent research and students' participation with audit meetings, in-class activities and group work within the cross-cultural module cohort.
- Information media and technology literacy is promoted through the exploration of online documentation, research skills and learning how to filter information to evaluate what evidence is valuable and what can be discarded.
- The 21st century core subjects of global awareness, sustainability and business literacy emerge through the taught sessions, peer-to-peer learning, audit meetings,

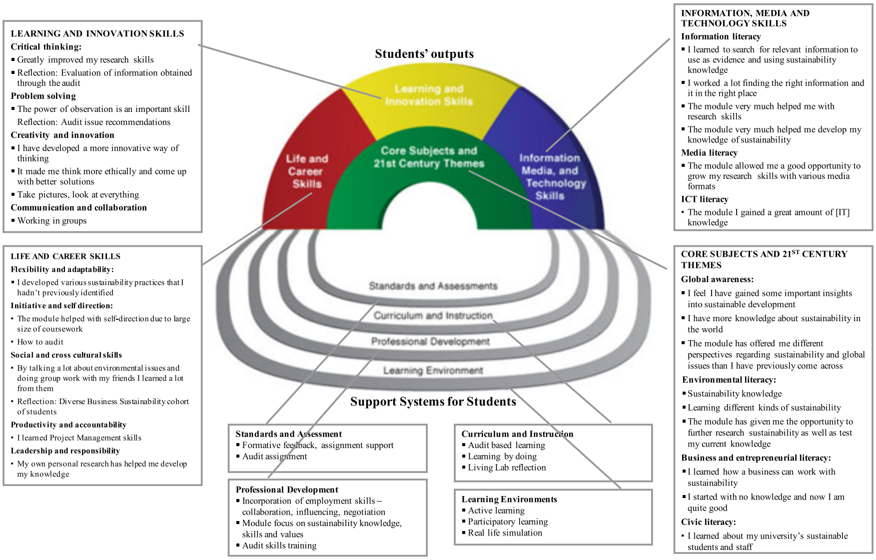

Fig. 1 Assessing the value of ABL for 21st century learning (Partnership for 21st Century Skills 2007)

independent research and completing the audit, evaluating findings and designing improvement solutions.

A support system for students aligned to the curriculum and instruction, learning environments, professional development and standards and assessments, considered the foundations for 21st century learning (Partnership for 21st Century Skills 2007), are integrated into the Business Sustainability module.

The ABL support system offering formative feedback, support, guidance and learning scaffolding through audit meetings, audit skills training, knowledge development activities etc. in a real world, relevant environment can achieve desired 21st century student outcomes and module learning outcomes: sustainability knowledge and skills. The use of the university as the audit environment provides a real world setting in which students can develop the appropriate knowledge, employment skills and real world connections to make the learning relevant and engaging recommended by Partnership for 21st Century Skills (2007).

8 Impacts and Implications

At the basic level, the Business Sustainability module taught at Worcester Business School provides EfS for Level 5 undergraduates and so contributes to the closure of the sustainability skills gap identified by Benn and Dunphy (2009). The findings of this study suggest ABL is also able to promote skills for sustainability advocacy and generate the students' outputs and student support systems that can achieve the 21st Century learning, enabling students to be productive learners and successful in life, work and citizenship. These 21st century learning student outputs have been achieved by the design and delivery of an innovative approach to EfS which is grounded in a real world context and utilises active learning for relevant topics that can engage students in deeper learning, enhance knowledge and skills for sustainability advocacy and employment skills. Together these can further the development of sustainable futures.

The research findings suggest ABL may encourage students to develop new ways of thinking and empower students to evaluate the evidence provided in the live case study, in-class activities, taught sessions and audit meetings with sustainability practitioners to make informed judgements of the university's sustainability performance. This may produce the new learning culture that can initiate the new ways of learning and thinking advocated by Rieckmann (2011) and Molthan-Hill (2014) to enable students to make the responsible and ethical management decisions recommended by Stough et al. (2018).

Students' reflections on their experience of auditing suggest ABL can contribute to the development of sustainability knowledge and skills that are considered a vital contribution of universities in developing sustainable futures (Chalkley 2006; Rieckmann 2011; Quality Assurance Agency for Higher Education 2014) and help meet society's demands for responsible business (Adomssent et al. 2014). ABL can also contribute to the provision of employment-ready graduates through the closure of the sustainability skills gaps and equip students with the sustainability business skills demanded by organisations (Docherty 2014). Through preparing and undertaking an audit and reflecting on findings to propose improvement actions, ABL may also encourage the generation of students' higher cognitive skills such as reasoning, synthesising, conceptualising, evaluating and communicating. This can help close the cognitive skills gap identified by Sadler (2016).

The opportunity for ABL to develop research skills alongside sustainability knowledge and skills emerged in the analysis of survey responses. The independent research required for the assignment, peer-to-peer learning and tutor-to-student learning incorporated within the module may generate these research and sustainability skills. This will be valuable for students to feed forward into their future academic career, particularly their independent research project undertaken at Level 6.

The author recognises that this one-time study may have some limitations. The small study size limits firm conclusions being made and anonymity of participants prevents the specific development of knowledge being validated. However, the study offers an innovative approach to EfS and a novel methodology for business sustainability LTA as well as insights to others in the sustainability community developing experiential LTA in a real world environment. Future studies will address these limitations to validate further the findings of this study.

9 Conclusion

The study presented here contributes to the debate into effective LTA approaches to EfS and to the delivery of students' preferences for active, collaborative experiential learning and extends the body of knowledge on the value of audit-based learning for EfS.

Overall, the research findings presented and evaluated through the 21st Century Learning Framework suggest ABL can provide a challenging task in a cognitively demanding, real world environment that engages students with EfS and develops sustainability literacy and employment skills. The use of ABL within the business sustainability module appears to have produced a new learning culture that can promote and deliver sustainable futures and contribute to the closure of sustainability and cognitive skills gaps. Students' reflections on the module and their audit experience highlight ABL's ability to engage students in new ways of learning and thinking and empower them to take responsibility for identifying their learning needs.

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Enhancing Student Engagement in a Sustainability Class: A Survey Study

Liguang Liu and Lianhong Gao

Abstract Student engagement in the classroom influences learning outcomes. As part of the initiatives towards higher education for sustainable development (HESD), it is important to create general education courses that focus on sustainability and is open to all majors and grades. It is also important to conduct and assess pedagogical practices to increase student engagement in such courses. Taking teaching of a sustainability course at the Central University of Finance and Economics in China as a case, this paper provides an assessment of the factors that influence student engagement in the classroom. By combining survey results of students' perceptions and teachers' reflections on engagement, this chapter suggests approaches of enhancing student engagement by absorbing students' contributions, improving communication and pedagogy and adopting a whole-institution approach.

Keywords Student engagement · Sustainability · Higher eduction institutions · China

1 Introduction

Education has an important role to play in the promotion of sustainable development. In 2005, the Decade of Education for Sustainable Development (DESD) was declared by the United Nations to integrate principles and practices of sustainable development into education. With the Millennium Development Goals (MDGs) replaced by the Sustainable Development Goals (SDGs), the links between development and sustainability have been made much clearer, calling for greater emphasis on education for sustainable development (ESD) efforts. With a roadmap for implementation of ESD, the Global Action Program (GAP) has since been launched to enable strategic focus to educational efforts in shaping a sustainable future (UNESCO 2014).

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Since the SDGs cover the broad sustainability themes of economic development, social inclusion and environmental protection, their implementation requires substantial and high-quality inputs of knowledge, skills, attitudes and values from the higher education sector. Higher education institutions (HEIs) now "have the responsibility, more than ever before, to integrate sustainable development into all their teaching, research, community engagement and campus operations" (Mohamedbhai 2015). Although campus greening practices have been widely implemented and whole-institution approaches been suggested, it is still challenging to meet the requirement of holistic and transformational ESD (Leal Filho et al. 2015; Shiel and Smith 2017).

By integrating sustainability into curriculum development, universities gain opportunities to restructure their use of resources and to enhance competence in teaching, research and community partnership. The class is perhaps the most critical place where students gain the knowledge, skills and motivation to understand and address the SDGs. Among many factors that influence learning outcomes, student engagement in class has tremendous leverage and should receive more attention. Furthermore, due to the interdisciplinary nature of ESD and the need for integrating theory with practice, enhancement of student engagement has been taken as an essential component of sustainable campus and community practices at many universities (ISCN 2018).

This chapter adopts a case study approach, describing the creation and implementation of a sustainability course offered by the Central University of Finance and Economics (CUFE) in China. What is distinctive is the focus on student engagement and the discussion of possible drivers in support of this goal. Evidence comes from questionnaire-based surveys in assessing student engagement in class, as well as teachers' reflections on the teaching process of the course. Built on prior research (Liu 2018), the paper uses the CUFE as an instrumental case to gain a broader appreciation of the issue of engagement in sustainability teaching and learning.

The chapter will proceed as follows: The next section reviews the literature of student engagement and puts it in the context of sustainability education. The chapter then continues by providing an outline of China's HESD governance and the institutional context of the CUFE. This is followed by sections firstly containing the survey procedures and results and then the teachers' reflections on the results. Finally, the conclusion provides a summary of the findings.

2 Student Engagement in Higher Education for Sustainable Development (HESD)

2.1 Student Engagement

Literally, engagement points towards active involvement, commitment and concentrated attention, although more than mere involvement or participation are implied. It requires feelings and sense-making as well as activity (Harper and Quaye 2009).

According to Trowler (2010, p. 5), "acting without feeling engaged is just involvement or even compliance; feeling engaged without acting is dissociation."

Increasing engagement is taken as an essential part of optimizing learning outcomes (Kuh et al. 2005; Gurung and Schwartz 2013). Unlike other types of metrics that focus more on student selectivity and faculty credentials, student engagement provides an alternative metric for measuring learning experiences and success in education. It is positively related to persistence and academic performance (e.g., Gurung and Schwartz 2013; Gettinger and Ball 2007). Besides, as an opposite term to alienation, engagement represents qualities of attachment, inclusion, integration or empowerment in relation to people, work or the physical environment, thus "the promotion of student engagement should bring benefits to quality of life that are more fundamental than increases in school achievement" (Newmann et al. 1992, p. 28).

Focusing on engagement at a school level, Fredricks et al. (2004) define student engagement as a meta-construct that includes three dimensions: (1) behavioral engagement, in which students typically comply with behavioral norms, such as attendance and involvement and would restrain from disruptive behavior; (2) emotional engagement, in which students would emotionally experience affective reactions such as interest, enjoyment or a sense of belonging; (3) cognitive engagement, where students would be investing in their learning, seek to go beyond the requirements and relish challenge. Schlechty (2002) defines five levels of student engagement: authentic engagement, ritual compliance, passive compliance, retreatism and rebellion.

Research has shown that the social-cultural orientations are the most important factors affecting student engagement. Changing students' experiences within the school can enhance their engagement. Drawing findings from psychology, sociology and education, Newmann et al. (1992, p. 17) frame a model that captures three broad driving factors of student engagement: students' underlying need for competence, the extent to which students experience membership in the school and the authenticity of the work they are asked to complete.

Researchers use a variety of methods to assess student engagement, including self-reporting surveys, teacher ratings, interviews, direct observations and focused case studies, each with strengths and limitations. Results vary depending on how engagement is defined and measured (Fredricks and McColskey 2012). The National Survey of Student Engagement (NSSE), a survey mechanism most popularly used by universities in Canada and the USA, provides a useful instrument to measure college student engagement. Five domains are included in the NSSE: supportive learning environment, enriching educational experiences, student-faculty interaction, level of academic challenge and active and collaborative learning (Gurung and Schwartz 2013). Based on the NSSE and used by faculty to measure student involvement in a particular class, Ouimet and Smallwood (2005) developed the Class-Level Survey of Student Engagement (CLASSE). The student CLASSE requires students to reflect on their behavior both inside and outside the class, whereas the faculty CLASSE is used to compare faculty expectations with students' experience during the class.

2.2 Engagement in Sustainability Education at Universities

There has been a growing recognition of ESD as "an integral element of quality education and a key enabler towards sustainable development" (UNESCO 2014, p. 9). The GAP therefore sets goals for generation and upscaling of ESD actions. Robertson (2014, p. 302) identifies three conceptual pillars of ESD: biophilia, bioregionalism and experiential learning. She argues that since all human beings undergo certain stages of cognitive development, these three pillars form elements of ESD that apply at every stage of life, including higher education, where there is a need for critical thinking and interdisciplinary vision to cope with the challenges posed by a complex and interconnected world.

Universities play critical roles in driving global, national, and local knowledge dissemination and innovation in the achievement of the SDGs. Meanwhile, engaging with the SDGs also benefits universities by demonstrating university impact, reorienting SDG-related education and building civic and community partnerships (SDSN 2016). To succeed in this, universities need to design curricula to integrate sustainability into research and teaching. Three layers of student engagement can be distinguished in sustainability classes. Figure 1 summarizes the structure of student engagement in ESD governance. This layered structure is accorded with the requisites of curriculum design in sustainability education.

The innermost layer of student engagement, namely classroom engagement, highlights students' willingness to participate in routine activities related to their learning experience. It is a network of teaching faculty and students for the course offered. In this layer the engagement can be reflected through a host of behaviors, such as attending classes, submitting assignments, following instructions and involvement in class discussions.

The second layer involves campus engagement. It is about students' involvement throughout the learning environment on campus, and institutional efforts in curricu-

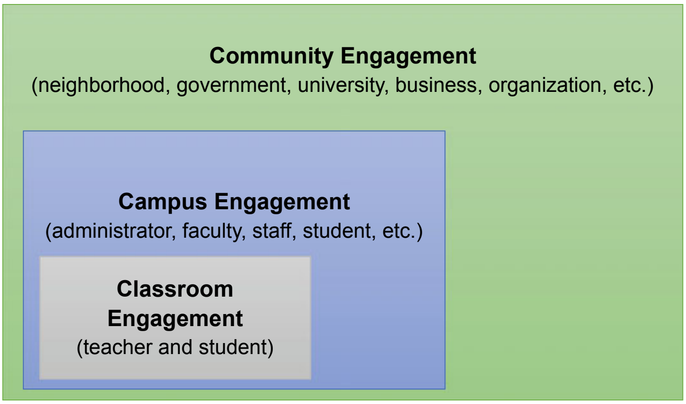

Fig. 1 Layers of student engagement in ESD governance

lum development and campus operations. It takes the university as a community for cultivating dynamic associations among faculty, staff and students. In terms of sustainability, engaged campus action covers activities of curriculum development, student associations, green buildings, landscape management, procurement, identity cultivation and the development of an inclusive environment.

Civic and community engagement constitutes the outer layer of engagement. It is about students' involvement in civic and community activities, often in the form of extra-curricular activities. Community-based learning and research are two pedagogical approaches that provide research and experiential learning opportunities for students. Actions to foster community engagement include strengthening the capacity of multi-stakeholder networks at local and community level and enhancing the quality of local platforms for learning and cooperation (UNESCO 2014).

Universities have partnered with global or regional networks such as the Inter-University Sustainable Development Research Program (IUSDRP), Higher Education and Research for Sustainable Development (HESD) and Global University Partnership on Environment and Sustainability (GUPES) to integrate sustainability into teaching, research and community outreach in higher education. Networks as these play a vital role in sharing knowledge and experiences, collaborating in quality improvement in teaching, research and community outreach, and promoting sustainability practices on campus.

3 The Context of Sustainability Education in Chinese Universities

3.1 HESD Governance in China

With rapid economic growth and substantial urbanization, China entered the 21st century with severe problems of environmental pollution and ecological degradation. The Chinese government has taken measures to balance economic growth with environmental protection, including mapping out new development goals and promulgating more rigorous regulations. In 2008, the National Environmental Protection Administration was reshuffled from a vice-ministerial agency to a full Ministry of Environmental Protection (MoEP), and a leadership committee was formed and led by the State Council to coordinate all relevant agencies to cope with energy conservation and climate mitigation activities.

Several ministries have played substantial roles in promoting policies and reforms for sustainable development. In the early 1990s, the Ministry of Science and Technology (MoST) led the drafting of China's Agenda 21 and implementation of sustainable development studies. Since 1998, with its broad power mandate, the National Development and Reform Commission (NDRC), formerly the planning commission, has replaced the MoST as the prime authority in development and cooperation, both domestically and internationally.

With respect to the HESD initiatives in China, the Ministry of Education (MOE) works as the direct regulator. It takes charge of overall planning, coordination and management of all educational systems in mainland China. By 2015, China had more than 2560 universities and colleges, hosting 28.2 million students. The anticipated increase in enrollment results in increasing pressure on the labor market. A recent estimate showed that approximately 8.2 million college students would graduate in 2018 (Xinhua News Agency 2017).

In China, public universities are often tiered into the central and local level. At central-level, 75 universities are directly affiliated with the Ministry of Education. These universities are well-funded and regarded as top-tier universities, whereas local-level universities are under the control of provincial governments, numerous in number but smaller in scale, less prestigious and less funded. Private and independent HEIs do not receive funding from the government and face severe challenges in terms of policy inconsistencies. There are some foreign-funded universities in China, however, in-depth cooperation is reportedly frustrated by state intervention on academic freedom and independence (Onsman and Cameron 2014; Huang 2018).

The Chinese government adopts and leans on a differentiated supporting strategy to enhance higher education competence and build world-class universities. Among all initiatives, Project 211[1] and Project 985[2] are the most popular. Nevertheless, these two projects have been widely criticized as aggravating centralization and imbalance of educational funding among universities and local development (e.g., Serger et al. 2015). Late in 2017, the Double First-Class University Plan was issued by the MOE, aiming to create world-class universities and disciplines by the end of 2050. The new plan replaces Project 211 and Project 985 and spreads funding to more universities and disciplines.[3]

China's Agenda 21 initiated the tasks of strengthening environmental education in primary and secondary schools, developing curricula and materials for universities, as well as introducing post-graduate courses on sustainable development. In 2010, the MOE publicized the National Outline for Medium- and Long-term Education Reform and Development (2010–2020), claiming that due attention shall be paid to sustainable development (MOE 2010). To date various efforts have been made to reorient teaching and research at Chinese universities, bringing sustainability practices to campus. According to Niu et al. (2010), approximately 50% of universities in China have launched general courses linked to sustainable development, and almost all universities have begun to orient their curricula in line with ESD.

[1]Project 211 is a national university project initiated in 1995 by the Ministry of Education in China, with the intent of raising the research standards of high-level universities and cultivating strategies for socio-economic development. The project includes 112 HEIs up to the mid-2000s.

[2]Project 985 was launched in May 1985 to promote the development and reputation of the Chinese higher education system. Till Project 985 closed its door for entry in 2011, it includes 39 universities from the list of Project 211 universities.

[3]The full sponsored university and discipline list of the Double First-Class Plan was published in September 2017, including 42 first class universities (36 Type A schools and 6 Type B schools) and 465 first class disciplines (spread among 140 schools including the first-class universities).

Following the guidance of the MOE and led by some pioneering universities, more Chinese universities have set up cooperative networks in communicating and disseminating green campus experiences and integrated green university initiatives into their development strategies. In 2011, eight Chinese universities formed the China Green University Network and drafted guidance for conservation-oriented campus construction. Meanwhile, the MOE increasingly emphasized education related to innovation and entrepreneurship in higher education in recent years.

3.2 The Central University of Finance and Economics as a Case

Recent research has taken the Central University of Finance and Economics (CUFE) as a case and studied students' perceptions of a newly created sustainability course that is open to all majors offered at undergraduate level (Liu 2018). This follow-up study focuses on approaches to enhance student engagement in this sustainability class.

The CUFE was established in 1949 and is under the direct leadership of the MOE. As a medium-sized university located in Beijing, the CUFE hosts 29 schools, with around 18,000 students, 1180 academic staff and 570 support staff. It includes 50 undergraduate programs, 76 master's programs, and 31 doctoral programs. The university owns a downtown campus and the suburban Shahe campus which is 30 km to the north. The Shahe campus hosts about 1500 first-year master's students and 7500 undergraduate students of all classes, exclusive of senior undergraduates.

The CUFE is one of the national Project 211 universities and in 2017, the discipline of applied economics was selected to be in the Double First-Class Plan. Due to the popularity of disciplines in finance and economics and its location, CUFE has become one of the most sought after universities in China. In 2016, CUFE issued a new five-year plan, aiming to become a distinctive, multidisciplinary and internationalized high-level research university (CUFE 2016). This strategic plan emphasizes the adherence by CUFE to the vision of sustainable development and takes conservation-oriented campus initiatives as a priority task in its mission of infrastructure construction. However, the CUFE has not yet established an official sustainability mission and coordination office.

4 Surveying Student Engagement and Results

4.1 Course Creation

A 12-week, 36 contact hour introductory sustainability course, with title "Sustainable development and the global challenge" was created in the fall semester of 2016 on Shahe campus. It is an optional taught course under the general education module "Science, technology and environment". The course is intended to broaden students' horizons and complement their major course study. Course lectures cover a number of topics, such as the history of sustainable development, energy and environment, economic development and social equity, population and public health, and climate change. Students are encouraged to raise questions and share their experiences in class. In 2016, as many as 250 undergraduate students took the course and a questionnaire survey was conducted to investigate undergraduates' perceptions of the course arrangement and their interests. Results showed that students had diversified interests in sustainability topics as well as lectures in class. Although most students had limited knowledge about the meaning of sustainable development before taking the course, they regarded the course as useful and helpful and claimed that their expectations were achieved after taking it (Liu 2018).

This follow-up research builds on the prior research conducted in 2016 and focuses on investigating and discussing student engagement throughout their course study. In the fall semester of 2017, the CUFE adjusted the general education course plan, and the sustainability course was arranged in evenings over a period of 18-weeks, 2 h per week. The class attracted 84 students, including 51 female and 33 male students. Students are from 34 undergraduate programs in 15 schools. Categorized by their grades, there are 25 freshmen (class of 2017), 54 sophomores (class of 2016), and 5 junior undergraduates (class of 2015).

In general, the pedagogical approaches changed very little from 2016 to 2017, with the course structure consisting of the same modules (Liu 2018). Concerning the contents of the lectures, there are some changes and updates. Previous topics such as "indicators of sustainability measurement", "research inquiry methods" and "political thoughts", as done in 2016, have been replaced in 2017 by the revised topics of "network economy", "ocean and polar affairs", "sustainable community management", etc. The new arrangement utilizes survey findings from the 2016 class and incorporates updated knowledge and information on relevant topics.

4.2 The Questionnaire Survey

In 2016 a questionnaire survey was conducted to understand students' perceptions on course contents and arrangements (Liu 2018). This follow-up study is designed to focus on the students' class engagement in the same course in 2017. In order to extract sufficient information on perception changes associated with learning during the course, the questionnaire survey conducted in 2017 adopts the logic that the baseline data of the pre-test survey are to be compared with the follow-up post-test results after some intervention occurred. On the one hand, by focusing on the same group of students, the two surveys in 2017 keep track of the learning progress of each student. On the other hand, since some of the 2017 survey questions correspond to the survey in 2016 (Liu 2018), a deeper understanding of perceptions of students develop, while also allowing generalization and comparison of perceptions between the two consecutive years.

Since the level of student engagement and survey context are often issue-, methodology-, space- and time specific, the pre- and post-tests are not strictly experimental. Students present in the class of 2017 were invited to complete two questionnaire-based surveys. These surveys were taken in the first week (week 1) and the last week of the tuition period (week 18) respectively and each took about 15 min to complete. The students were informed that honest and straightforward responses would be preferred, and that individual responses would be kept confidential and not be used in any other way. Through collecting the information about students' interests, perceptions of the course, cognitive skills and engagement performance, this study intends to identify possible gaps in the existing knowledge about engagement in sustainability teaching and learning and subsequently suggests some solutions.

In this case, the first survey, conducted in September 2017 with a valid response rate of 86% (76 of 84 students), consists of the same questions as for the previous class in 2016. The second survey conducted a few months later in December 2017, with a response rate of 95.2% (80 of 84 students) captures students' opinions of participation, classroom engagement and suggestions for the course. The second survey is adapted from a sample CLASSE survey to measure student involvement in the class (Gurung and Schwartz 2013), with all choice items focusing on self-reporting evaluations of engagement activities, cognitive skills and class atmosphere. There are some open-ended questions, to which students can respond with their own ideas, comments or suggestions.

4.3 Results

Although the class in 2017 had fewer students compared with the previous class in 2016, does the smaller sample restrict our ability to generalize? Do they share a similar learning experience and interests in sustainability course learning? What new findings can be obtained from the more recent surveys? The first survey indicated no significant difference between the classes conducted in 2016 and 2017 in terms of prior engagement of students with sustainability. In 2016, 83.4% of the students indicated that they have not taken a sustainability course before college, whereas in 2017 this was the case for 85.5% of the students.

Students were asked to assign a number from 1 (no knowledge at all) to 5 (full understanding) to indicate their existing knowledge about key historical events associated with sustainable development. Five iconic events were selected: 1972 Stockholm Conference; Brundtland's SD definition; Rio Summit and Agenda 21; adoption of the MDGs in 2000; adoption of the SDGs in 2015. Figure 2 shows the comparative percentage results for the two classes. It is fair to say that the students from the 2016 class and the 2017 class are not significantly different. With an item on the Kyoto

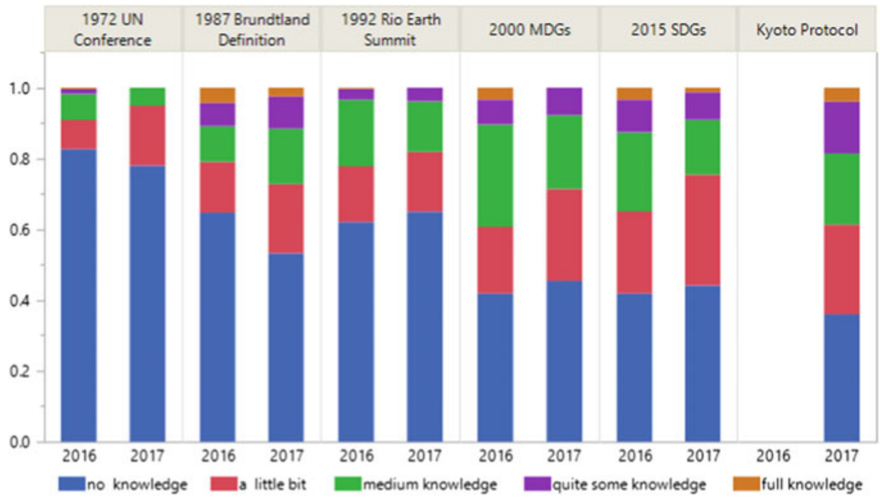

Fig. 2 Comparison of prior knowledge on sustainability between the 2016 and 2017 classes

Protocol and Paris Agreement added in 2017, the trend seems obvious that students are more knowledgeable about recent events.

Students were asked to choose SDGs they are more interested in and identify their likes and dislikes from a number of topics that are proposed to be taught in the course. The likes and dislikes listed by the 2017 class cover a wide spectrum, but are quite similar to those for the 2016 class. In general, the top-selected topics include the network economy (51.9%), environmental protection and pollution control (46.8%), quality education (40.3%), climate change and the carbon market (36.4%) and issues on China (32.5). Political theory and state governance (47.4%) was chosen to be the most disliked topic, followed by social inquiry methods (32.9%) and the history of sustainable development (31.6%). Students could also add topics of their special interests, with more than 50% of the students giving replies. The teacher responded that their perceptions and suggestions would be considered in arranging future classes.

Students also responded in terms of their habitual behaviors and their perceptions of pedagogy and class atmosphere. Mobile phones (97.4%) and the internet (94.8%) are the most popular tools that they use to obtain information and to communicate. 39% of the students spend 2 to 3 hours per day on the internet, while this increases to more than 3 hours per day for 29% of the students. In the multiple-choice item requiring information about the type of news that interest them, entertainment news ranked first (72.7%), followed by domestic news (66.2%), disciplinary information (51.9%) and international news (42.9%).

Analysis of the questionnaires indicated that the majority of students (81.8%) anticipated that the lecturer would be able to adopt various ways to teach in class that would go beyond traditional instruction. This included video playing (75.3%

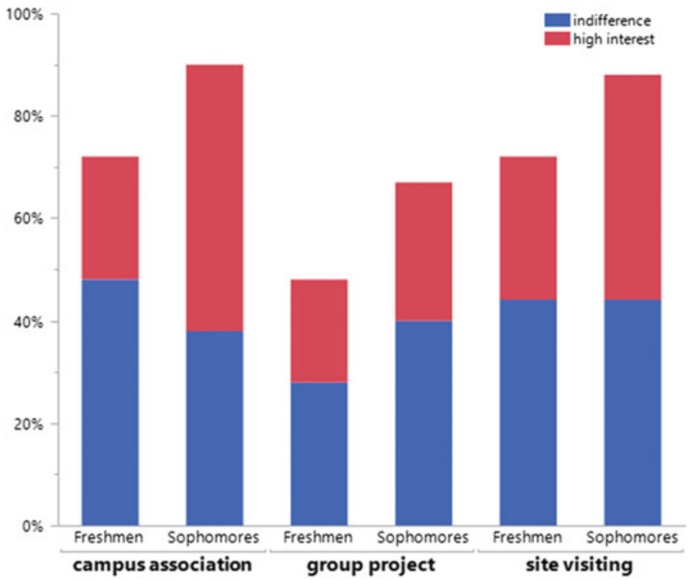

Fig. 3 Comparison of interests when including extracurricular activities

of responses) or case discussion (57.1% of responses). They also anticipated that their performance would be evaluated by a term paper or by an open-book exam in class. About one third of the students (35.1%) indicated an interest to participate in out-of-class activities. Asked to rank the extent of their interest in the type of group activities on a scale of 1–5, the students mostly expressed a lukewarm attitude (rank of 3) for green association activities (40.3% of students), campus site visits (42.9% of students) and group projects (33.8%). However, second-year students (sophomores) have shown much greater interest in out-of-class activities than first-year students (freshmen), as shown in Fig. 3. Regarding satisfaction with the location, time and size of the class, the highest satisfaction rank was allocated respectively by 58.4, 75, and 46.8% of the students.

The second survey gave students an opportunity to self-review their learning experience, especially the aspect of participation during the class. With regard to measuring the engagement activities, two indicators were used, namely pre-class reading performance and contributions to class discussion. Survey results showed that 85.1% students can generally complete the reading assignment, but they participation in class discussion was not active: 21.3% students reported that they never participated in class discussion and 60% reported they participated less than twice.

Table 1 shows students' responses to utilisation of cognitive skills and other educational practices. In general, the class attendance is self-reportedly high, but this is more in terms of compliance than engagement. This is confirmed by the teacher's observation that the class is usually quiet and orderly, nevertheless, quite a number of students pay little attention to the presentation and are tepid to its content. Since

Table 1 Self-assessment of cognitive skills and educational practices

Part	Item	Low (%)	Some (%)	Quite a bit (%)	High (%)
Cognitive skills	Memorizing facts, ideas and readings	6.3	45	48.8	0.0
	Analyzing basic elements of idea, experience or theory	25.1	41.3	23.8	1.0
	Synthesizing ideas/information into relationships	3.8	20	41.3	35
	Making judgments about values, arguments or methods	7.5	21	40	31.3
	Applying theories to practical problems	6.3	28.7	31.3	33.8
Educational practices	Attendance	1.3	5.0	8.8	85.0
	Interest in learning the course	7.5	73.8	17.5	1.3
	Difficulties in learning the course	0.0	7.5	73.8	18.8

most students just started their university experience, they haven't yet established the relevance of this optional course to their majors. Students identified reasons that limited their participation and engagement in classes. Their responses were diverse: low acquaintance, lack of interest in some sustainability topics, possible irrelevance to the course grading, lack of knowledge, insufficient discussion time and weak demand of the teacher.

Students understand that public policies play crucial roles in addressing sustainable development challenges. In total 89.9% of the students thought it necessary to further their study of public policy by taking additional relevant courses. Furthermore, policy issues are always connected to the discussion of politics. Students were also questioned about their views on discussing the politics behind policies. In this regard 5.1% of the students thought that it is of little relevance to their current studies. They therefore have no interest in it since they think that they will never have to deal with it. In addition, 66.7% of the students admitted that they have some interest in it, but regarded it as a sensitive topic, while 19.2% of the students recognized their concerns and showed interest in doing in-depth study about it. Lastly 9% of the students responded they have never thought about it.

5 Teacher's Reflections on Student Engagement

This section provides the teacher's reflection on student engagement in the sustainability course, based on the response from the surveyed students. This reflection attempts to reach congruence between what the teacher values and what students report on in terms of their activities, with a view to enhance student engagement in the classroom.

Although the number of students in the 2017 class that participated in the surveys was much lower than for the 2016 class, and individuals may vary greatly in terms of experience, interests and identity, some results of the survey (e.g., awareness of historical events) have shown that two groups of students share quite similar background and perceptions. No doubt, this has lessened the limitations of the sample size to some extent. In addition, the self-reporting surveys on student engagement are complemented with in-class observations and discussions, as well as some after-class contact sessions. The rest of this section deals with some reflections on student engagement in class and lessons that can be learnt from this.

5.1 Improving Student Engagement in the Classroom

Without knowing the students' perceptions and considering their interests, it is difficult to have an engaged class. Although students choose this optional course out of their free will, many factors determine their choice, including personal curiosity, usefulness, class time, the pass rate, academic and credit requirements as well as the perception and influence of others. The surveys conducted in two consecutive years, 2016 and 2017, indicated that students have diversified interests in sustainability topics and that they expect to learn something that could be useful for their specialty course study. Given the interdisciplinary and complex nature of sustainability topics, it is not realistic to expect to capture the interest of all students in all topics, and to have all students authentically engaged throughout the class. Continued pedagogical research on teaching and learning can help with the identification of more "focused" topics that are tailored to the curiosity of students.

Students are more engaged in the classroom when they already have some knowledge of the selected topics. Some pre-class reading by students are necessary and indispensable. From the feedback provided by students about their course learning experience, it became clear that they did not have the time to read the materials as requested by the teacher. They explained that their time was occupied by specialty course learning and school activities. Nevertheless, for phenomena of which students have practical experience, as income inequality, air pollution and urbanization, it is useful to take some time and encourage them to ask questions or to let them present their observations. The teacher can then respond to their questions and add more insights during the class. Another benefit from student participation in class is that it provides an opportunity for students to get to know each other and to start communication. Therefore, instead of the teacher having to face all students, students can be linked to each other during classes as well.

First-hand observation and experience from teachers contribute to the engagement in classes, even with regard to less familiar issues. In one class, as an example, the teacher gave a presentation of 30 min on Antarctic exploration and China's polar investigation program. The teacher integrated instruction with observations and some of the stories gained during a site visit to a polar investigation training center and interviews with the expedition team. In this case, most students listened attentively.

The 2017 survey also shows that for activities outside the class, second-year students have a stronger desire to attend compared with first-year students.[4] This could be due to the fact that with more knowledge accumulated, second-year students are more willing to be involved in extracurricular practices and research projects. This presents some insightful ideas for future curriculum development and content improvement. In short, to have an engaged class, instead of compliant class, the teacher needs to carefully plan and manage classes and make adjustments to the pedagogy to meet the needs of the students. Besides, pedagogical research also assists teachers to understand their students better, including their attitudes, habits, perceptions, prior knowledge, plans and so on, which creates a positive learning environment for increased engagement.

5.2 Valuing Students' Feedback and Making Stepwise Change

The course "Sustainable development and the global challenge" is listed as an optional course in the 2017–2018 CUFE curriculum catalog among one of the hundreds of general education courses that are open to undergraduates. Since the course has been taught for two years, and surveys about student's perceptions of the course have been conducted, the teacher can use this input to make improvements in course design and class communication. Although the analysis of questionnaires and the evaluation were taken after completion of the course in respectively 2016 and 2017, the similarity in class composition of these two years imply that the performance and suggestions from the 2016 class can provide a useful frame of reference for the 2017 class. A virtuous teaching and learning cycle forms when incorporating students' feedback into teaching practice.

The final assignment for the class can be taken as an example: all students received the task of describing some green campus activities which they had attended or planned to attend. Another task was to design a group research project, assuming

[4]There are only four valid samples from the third-year undergraduate group.

they could form groups to complete a sustainability project within one semester. The finalized research report should include items such as a title, background information, research questions, methodology, implications, implementation steps and reference literature. Although students worked independently on this task and it was a satisfying experience to find that there were several brilliant and intriguing ideas from students. These ideas can definitely provide insights to students in future.

As a matter of fact, some reforming attempts have been taken incrementally. An example is the development of a second related sustainability course, named “Sustainable campus management and community engagement”. The course will be arranged in the spring semester and includes a practicum module and group project. The envisaged class will be open to second-year students, with an upper limit of 30 students. Another faculty member will join and cosponsor the class guidance.

It should be noted that a lesson learned, and certainly one that has constantly been re-learned, is that political sensitiveness is one factor that obstructs in-depth communication and class discussion. Two thirds of students have admitted to this in the survey. With strong authoritarianism and censorship imposed by the government, any doubts about the current political regime are regarded as “politically sensitive” issues. Teachers and students are aware of that and have learned to regulate the opinions that they express in this regard. However, this blindness to political realities not only deprives them of the opportunity to change, but also leads to the reduction of empathy. This is at odds with social responsibility, that lies at the heart of sustainable development. The authors argue that it is not a smart choice to be heedless of discussing “politically sensitive” issues, when most students may be less inclined to accept this position. An alternative approach may work better. That is to introduce some relevant academic theories around the discussed topics, such as the essence of democracy, the multiple-dimensions of development and the politics-government-policy nexus. While teachers need not make value judgments, students can be guided by their curiosity to take further consideration of these type of matters after class.

5.3 Initiating a Whole-Institution Approach to Enhance Student Engagement

Figure 1 has shown the three-layered structure of student engagement. The innermost layer, referring to engagement in the classroom, could not be separated from the campus life and more broadly the local community life of students. A systematic approach towards student engagement would entail the integration of class instruction with experiential learning through community involvement initiatives. Students can apply what they have learned during class in practice, while at the same time bringing on-site and hand-on experiences back to class and share these with other students. Therefore it is important for the university to build platforms, make innovations in curriculum development and facilitate opportunities for faculty and students to enhance engagement in general education courses.

Universities can adopt a whole-institution approach to optimize their role as agents of change with regard to sustainability. This whole institution approach explicitly links curriculum, research, operations and outreach activities, and encourage a collaborative space within the curriculum for students, academics and managers to critically reflect on the sustainability performance of the university (Mcmillin and Dyball 2009). This approach has been widely promoted and adopted in the world. Five steps are recommended to start and deepen universities' engagement with SDGs (SDSN 2016).

The CUFE is on its way to become a first-class university and has clearly expressed its intention to promote sustainability on campus. The university does not have an official sustainability mission and coordination office at this stage. As shown in this case study, sustainability education is confined to specific course teaching, being generally isolated from research and disconnected from sustainable campus operations. However, the creation of the sustainability course is a foot-in-the-door attempt towards improvement in the university's performance with regard to sustainability. The Office of Teaching Affairs requested schools to improve the curriculum for each major and to evaluate the necessity of prerequisite as well as optional specialized courses. An application for creating a general education course will be unitarily evaluated and completed by this Office. In terms of research, a new research hub, the Center for Global Economy and Sustainable Development was established by the Scientific Research Office to promote international collaborative research and broaden its traditional focus on finance and economics. How to bridge and balance the different areas of education, research and operations is still a challenge to the university. The CUFE can involve all levels of faculty, staff and students into the discussion of where the current strengths and weaknesses are, and where there may be room for improvement.

6 Conclusion

Many universities have responded to the challenge of sustainable development and added impetus to inspire curriculum development. Engagement is an important factor that influences outcomes of teaching and learning. Taking the experience gained with the teaching of a sustainability course at a Chinese university as a case, this study analyzed factors that influence student engagement in class by integrating survey results obtained from students with reflections by the teacher on lessons learned.

Engagement in the classroom builds on good communication between faculty and students and their mutual efforts to improve teaching contents and pedagogy. The curricula can be redesigned to be more connected to inspire collaboration between disciplines and between faculty and students. Students' feedback on their experience and suggestions for improvement provide valuable "process assets" that needs time to mature. In addition, student engagement has the greatest chance of success when a systematic whole institution approach is adopted so that courses can be aligned with program development, scientific research, institutional change and even community and social development.

Change can be initiated from the bottom, or else it can be lead from the top. The empirical case of CUFE shares the experience gained through the creation of an optional course on sustainability. From a broader perspective, it is just the effort of "picking the low-hanging fruit", which means there is a big gap, as well as a great potential in achieving successful sustainable campus management by integrating the SDGs into the curriculum. Such endeavors have been widely tested with growing passion by many universities. However, to realize transformation towards an engaged class and a sustainable campus, strong leadership and governance reform are fundamental requirements.

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Opportunities and Challenges of Digitalization to Improve Access to Education for Sustainable Development in Higher Education

Oliver Ahel and Katharina Lingenau

Abstract Both the implementation of sustainable development and the integration of digitalization in higher education are globally discussed topics. Combining these, digitalization could be the key to enlarge the scale of students getting access to Education for Sustainable Development (ESD). In this chapter the opportunities and challenges of digital transformation as a possibility to improve access to ESD in higher education are discussed. The chapter includes an introduction about the achievements in the integration of ESD in higher education and discusses the latest trends in digital transformation in higher education. Furthermore, a short overview about the main political programs to support ESD and the dissemination of the sustainable development goals (SDGs) is provided. Subsequently, the concept of the "Virtual Academy of Sustainability"—a successful project at the University of Bremen that teaches and promotes ESD via digital media—will be introduced and challenges and opportunities presented.

Keywords Higher education · Sustainable development goals · Digital transformation · Curriculum

1 Sustainability in Higher Education

This chapter provides an overview of the aspirations to facilitate sustainable development through education. It underscores the notion that sustainable development for all countries is only truly possible through comprehensive cross-sector efforts beginning with education (UNESCO 2014c). Furthermore, the role of digitalization for improving Education for Sustainable Development (ESD) and championing the Sustainable Development Goals (SDGs) will be examined. To illustrate this point, a case study about the Virtual Academy of Sustainability at the University of Bremen

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will be presented. Building on the case study, this chapter discusses several pertinent conclusions and the potential of digitalization for promoting ESD.

1.1 ESD in Higher Education

In 2002, as a proposal of the Rio +10 Conference on Sustainable Development, the Decade of Education for Sustainable Development (DESD, 2005–2014) was proclaimed by the United Nations General Assembly and overseen by UNESCO. The goal of the decade was to "integrate the principles, values and practices that make up sustainable development into all aspects of education and learning." (UNESCO 2014a, p. 9). ESD requires teaching and learning approaches such as questioning of assumptions, working in teams and imagining future scenarios to enable learners to integrate knowledge about complex and interconnected issues like climate change, biodiversity and poverty reduction etcetera. Overall, the DESD worked towards a reorientation of educational systems and structures and pushed towards a reframing of teaching and learning (UNESCO 2014a). Notable achievements of the DESD include: (a) integration of national ESD strategies with coordinating bodies in most member states of the UN and (b) initiation of a reorientation of education systems with the integration of several ESD programs into curricula, especially with regard to early childhood education, primary and secondary education and non-formal education.

However, a comprehensive integration of ESD in the educational systems could not yet be achieved as several educational institutions and pedagogical approaches failed to fully embrace issues of sustainable development. In the realm of higher education, the systematical integration of ESD in curricula, research and operations was to a large extent still lacking by the end of the DESD, even though it has become common practice to increase awareness of ESD through one-time events, stand-alone courses, workshops and project-based activities (UNESCO 2014a). For example, in 2009 the German UNESCO Commission revealed that at that stage only 2% of the students in Germany had access to courses focusing on sustainable development (Deutsche UNESCO-Kommission 2009).

While much has therefore been done to advance ESD, the progress was clearly uneven and most member states of the UN acknowledged that more work was required for full implementation. Due to many unattained goals, UNESCO decided to initiate a follow-up program to promote the integration of ESD in all education systems, namely the Global Action Programme (GAP) on ESD. The GAP offers the education system another five years (2015–2019) to support the integration of ESD and to accelerate up-scale and deepen the transformation of education. The GAP aims to contribute substantially to the 2030 agenda for sustainable development through the following two objectives:

– Reorienting education and learning so that everyone has the opportunity to acquire the knowledge, skills, values and attitudes that empower them to contribute to a sustainable future.

– Strengthening education and learning in all agendas, programmes and activities that promote sustainable development.

In addition to these two objectives, the GAP defines five priority action areas, namely: (1) *Advancing policy*, (2) *Transforming learning and training environments*, (3) *Building capacities of educators and trainers*, (4) *Empowering and mobilizing the youth*, and (5) *Accelerating sustainable solutions at local level* (UNESCO 2014b). Since the target of the DESD from 2005 until 2014 was to integrate ESD in every education sector, the explicit requirements of ESD in the higher education system can also be found in the GAP. Policy has to make sure that ESD is integrated in all curricula. To achieve this goal, relevant indicator frameworks that establish standards for learning outcomes have to be developed.

To transform learning and training environments, higher education is addressed in the GAP in several ways. Higher education institutions have to integrate sustainability in all institutional processes: research, teaching, campus operations, governance, administration and policy. To promote this kind of change, research on the transformation of higher education institutions and systems is required. Furthermore, higher education institutions are challenged to train their teachers in ESD and also to develop further educational concepts about ESD. This includes the design of appropriate teaching and learning methods and concepts to mobilize and empower students as future leaders and decision-makers. Last but not least, by working in collaboration with the local economy or other institutions, higher education could contribute to sustainable development solutions at a local level.

However, despite the enormous and steadily growing number of students in higher education worldwide as well as the growing number of public, private and open and distance learning higher education institutions (UNESCO 2017) the number of courses which include ESD has not increased as anticipated.

1.2 The SDGs and Higher Education

Besides the DESD, the United Nations adopted the 2030 Agenda for Sustainable Development in 2015, which includes the 17 Sustainable Development Goals (SDGs) and 169 sub-goals. Their key aim is to achieve sustainable development in developed and developing countries by 2030 (United Nations 2015). The SDGs cover a wide range of complex social, economic and environmental challenges. Addressing them will require transformations in societies and economies. The goals range from *No Poverty* (Goal 1) and *No Hunger* (Goal 2) to *Reducing Inequalities* (Goal 10) and *Climate Action* (Goal 13) (a full list of the goals and targets can be found at https://sustainabledevelopment.un.org/sdgs).

Quality Education is mentioned as Goal 4, while ESD is specifically involved as Target 4.7. Arguably none of the SDGs will be achieved without this sector. This can be seen in the *Education for All Global Monitoring Report* (released in July 2014 by UNESCO), which reiterates that education is not only an end in itself but also a means to achieving the broad global sustainable development agenda.

Education, research, innovation and leadership will be essential in assisting society to address sustainable development challenges. Because of their unique position within society and their educational mandate, universities have a critical role to play in the achievement of the SDGs. As mentioned by the Sustainable Development Solutions Network (SDSN), universities can contribute to achievement of the SDGs in several ways:

- Teaching and learning: provide students with competencies required for sustainable development through ESD; develop and offer accessible education to all; provide expertise to implement SDG solutions; empower and mobilize young people; educate teachers and lecturers in SDGs and how to teach sustainable developments successfully
- Research: providing knowledge, technologies, innovations etc. to support the implementation of the SDGs by the community; transdisciplinary approaches to science; collaborating with developing countries and companies to implement SDG solutions; student training for sustainable development research
- Organizational governance, culture and operations: implementing the principles of the SDGs through own structures and operational decisions
- External leadership: strengthening public engagement and participation; helping with the design of SDG policies (SDSN 2017).

Even though the adoption of the SDGs is a recent development, several studies examining the integration and implementation of the SDGs in higher education or the steps to achieve Goal 4 *Quality Education* have already been published.

Despite all these developments, not only ESD but also the SDGs have not yet been fully integrated into the higher education system. *The Sustainable Development Goals Report 2017*, launched by the UN, reports on targets and steps which have been taken towards achievement of these goals. In general, the reports concludes that "… the rate of progress in many areas is far slower than needed to meet the targets by 2030" (UNSD 2017, Introduction, p. 4). In the field of education and specifically higher education, the UN reports on a lack of teachers trained in ESD at every education level (UNSD 2017) and therefore in igher education as well.

A study by Giesenbauer et al. (2017) about the integration of the SDGs at all educational levels in Germany, concludes similarly: Universities are still focusing mainly on receiving external research grants, to generate publications etc. The important role of appropriate and innovate teaching methods and content related to sustainable development is often not fully embraced. On a more positive note, this study indicates that a community of interdisciplinary sustainability researchers has indeed been established in higher education. Although several ways through which ESD finds its way into curricula can therefore be identified, integration in terms of concrete subjects are not that common (Giesenbauer et al. 2017).

2 Digital Transformation in Higher Education

The effect of digitalization in higher education is—similar to ESD—a widely discussed topic and a current socio-political challenge. Both approaches have a common focus: to create new learning and teaching formats to generate skills and competences which are required to address future problems, which are not known yet.

2.1 History and Current Trends

Digital transformation is shaping the human society these days like no other trend before. Digital transformation has a tremendous impact on the economy and on society, and for example changed the way the music- and retail, financial and culinary industries conduct their business. The impact of this change is very powerful, so that it is leaving an impression even on well-established and slowly changing systems such as higher education and especially the way that students are learning. Therefore digital media has become part and parcel of research, teaching and learning in higher education. The intensity of use of digital media differs from university to university and even internally from faculty to faculty. Usage varies from simple forms, like inclusion of power point slides during lectures, to more complex forms, such as campus management systems. The most common use involves electronic presentation or distribution of learning materials. This can be conducted in classic on-site lectures as well as in forms of open and distance learning.

Since the beginning of the twenty first century, it has become common practice to produce and provide videos of lectures. In the spirit of free education, numerous universities provide video lectures and learning material as freely available content on the internet. Research funding, the launch of online education platforms and the ongoing digitalization in other sectors caused a hype about Massive Open Online Courses (MOOCs) from 2010 onwards. As a result it has become impossible for universities to overlook the digital transformation. Within a short period of time, MOOCs grew to a common learning and teaching format used by many universities. Simultaneously, globalization triggered a phase of extensive change in the working environment, both inside and outside of universities. Working in interdisciplinary and international teams, self-management and virtual collaboration became more important and the use of digital media became a significant part of everyday life. Furthermore, the use of digital media was no longer limited to the consumption of content, with the creation of content by everyone also becoming common.

All these factors had very specific effects on teaching and learning in the higher education context. Even if digital transformation did not have the same effect on the higher education system as on other fields and MOOCs are no longer state of the art (because of overwhelming disadvantages as: too large groups, large differences in education level, high dropout rate, etc.) the trend of the digital transformation of higher education is continuing. The implementation of digital media in new learning scenarios is increasing and new active and collaborative formats, like inverted classroom models or blended learning scenarios, are continuously developed (HfD 2016). Apart from engaged lecturers, who have a personal interest in digital media, there are socio-political factors (e.g. the Bologna-Process and the guiding concept of lifelong learning) which contributed to the promotion of digital teaching at European universities (Pietrass 2011).

2.2 Opportunities Associated with Digitalization

After many discussions and years of research and development, the transformation towards and implementation of digital media in classrooms is now widely considered as a meaningful development (Mayrberger 2015). A trusted publication as the *Horizon Report: 2015 Higher Education Edition* of the New Media Consortium (NMC) (NMC 2015), which surveys short, mid and long term trends, technologies and developments in higher education, underlines the numerous advantages of the digital transformation. In this particular publication, virtual education is referred to as a meaningful alternative to attendance teaching. In addition to that, specific advantages as flexibility, accessibility and practical relevance are mentioned (NMC 2015).

Online lectures in particular give students the opportunity to study in a flexible way. Students get the opportunity to study at any time, at any place and at their own pace. To get access to content (e.g. learning material or videos of lectures) and process it in a self-guided way, fits the needs of students who have other obligations besides their studies and provides solutions for some of the everyday problems of modern society, such as full work programs and other time-related issues. Moreover, a specific advantage of digital teaching and learning is that it is oriented towards future job requirements. Most emerging markets provide several opportunities for jobs directly related to digital media (The World Economic Forum 2016). It is anticipated that occupations will progressively increase the use of digital media—also occupations in which it is not used as intensively yet (Ibid).

The use of digital media during learning prepares students to work in interdisciplinary contexts, which is useful for occupations based on digital formats. A positive social factor is that digital media provides the opportunity for the creation of collaborative learning platforms, which enable students and researchers to work together and experiment with new techniques. Furthermore, the use of digital media can increase the motivation to learn, the learning efficiency and the learning success of young people (Kerres 2016). Even though digital teaching cannot (and should not) necessarily replace attendance teaching, it can be a useful tool, which can assist lecturers in imparting knowledge and help students to prepare themselves for future challenges (Dräger and Müller-Eiselt 2015).

2.3 Limits and Challenges of Digitalization

It is in the nature of things, that complex innovations such as digital transformation are associated with some disadvantages and challenges. One major challenge is, that the various degree programs of different universities are each very specific, are based on different contents and follow different approaches. Taking differentiation into account, custom made structures have to be developed, digital teaching has to be integrated properly and course contents have to be linked to aspects of sustainable development. The concept of lifelong learning brings another challenge with regards the demographic aspect. Future learners will be a very diverse and heterogenic group, with different aspirations and user behaviors. The challenge is to take all these different factors into account, while providing efficient digital learning solutions. At a more basic level, not everyone has access to digital media or continuous internet connection. The mobile phone (smartphone), which has become one of the primary media in the world (eMarketer 2016) could be the key to spread ESD. The challenge is to create content that is compatible and also accessible offline.

Furthermore, higher education institutions are facing some general challenges, which digital transformation might assist them to cope with:

- Large numbers of students: Between 2000 and 2014 the total number of students in the world more than doubled from 100 to 207 million (UNESCO 2017). This increase in participation in higher education is explicitly demanded in the SDGs, but since universities are run on a tight budget, the quality of education may suffer.
- Diversity of students: The diversity of the students' lifestyles increased over the past few decades (Berthold et al. 2012). Many students have to work, even if part-time or as student assistants, sometimes have a family to support or may be involved in a traineeship. The demand for flexible higher education models is therefore increasing.
- Dropout rates: Besides family challenges and financial difficulties, the most common reason for quitting higher education is motivation issues or unsatisfying living conditions. This points towards the high demand for flexible and personalized education (HIS 2010).
- Internationalization: International cooperation and collaboration between universities are more and more common, as well as increased diversity in the different national backgrounds of students (Blight et al. 2003), which lead to challenges in their own right.

3 The Virtual Academy of Sustainability at the University of Bremen

As demonstrated, the usage of digital media can provide an opportunity to integrate both ESD and the SDGs in the curricula of higher education institutions in an effective, efficient, innovative and future-oriented way. The case study in this chapter deals with the Virtual Academy of Sustainability at the University of Bremen (hereafter referred to as the Virtual Academy), and shows how digital learning and teaching can be structured to contribute to ESD in higher education. In addition to presenting the core mechanisms that drive this project, the information presented in the following paragraphs are based on the observations by the five scientific associates involved in the project, as well as on the results of interviews and questionnaire surveys with participants in the learning environment facilitated by the Virtual Academy.

3.1 History, Strategy and Goals

The Virtual Academy is a third-party-funded project, supported by the German Federal Ministry of Education and Research. The mission of the Virtual Academy is to combine the opportunities offered by digital transformation with the socio-political imperative of providing ESD. Since its founding in 2011, the Virtual Academy is producing and offering online courses about a variety of sustainability topics for the broad European higher education community. Through these online courses, the Virtual Academy is supporting other universities to satisfy the need to provide ESD and therefore to work towards achievement of the goals of the DESD and the GAP (Fig. 1).

The learning experience facilitated by the Virtual Academy covers three aspects, namely: (1) learning videos, (2) the learning platform and (3) electronic assessment, which are now dealt with briefly one-by-one:

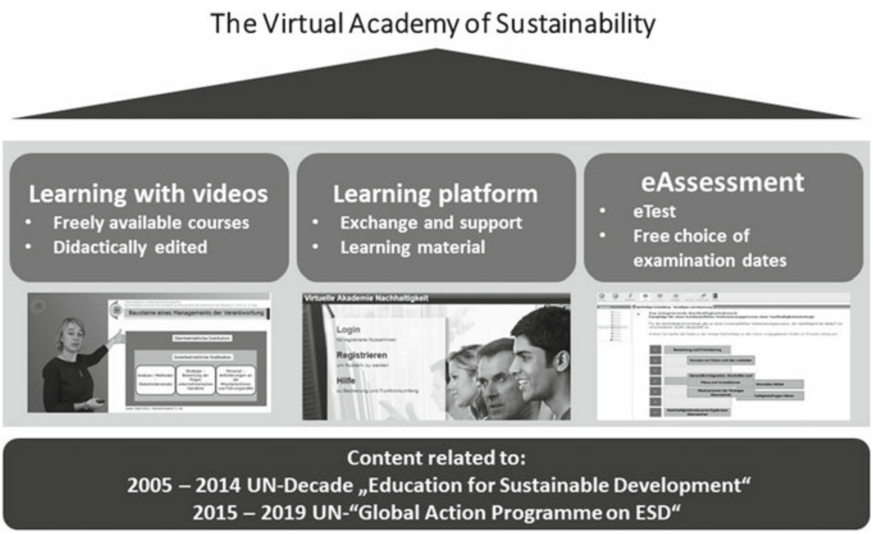

Fig. 1 The structure of the virtual academy

(1) Learning Videos

The concept of the Virtual Academy is based on producing and offering online lectures which universities can integrate into their own curricula. The core of these lectures are learning videos which are available at any time and free of charge on the homepage of the Virtual Academy, as well as on its YouTube Channel. Currently, the Virtual Academy offers 18 different online lectures on various sustainability themes. Of these lectures, 13 are in German, 4 in English and 1 in Spanish. Most of these lectures have a scope of 3 credit points, which equals a workload of 90 h. The online lectures cover a wide range of topics, e.g. worldwide migration, climate change and transition management. Each online lecture refers to one or more of the SDGs and focuses on a different aspect of sustainability: ecology, economy or society. Because the lectures have the character of basic level courses, bachelor's and master's students of all semesters and faculties can participate without great barriers to entry.

Structure of the learning videos
To meet the high expectations which are required from digital learning materials, the learning videos are based on a profound didactical concept:

- The videos are aligned with the ability of students to concentrate. Therefore, the online lectures are segmented into thematic chapters of 90 min, which are again segmented into three episodes of 30 min each. Two of these episodes are lectures, while one episode comprises an interview.
- The videos are connected to the set learning objectives. At the beginning of every episode, the learning objectives are provided in order to assist the students to orientate themselves during the period of self-study.
- The lectures include subsequent tasks for the period of self-study. Students can consolidate their knowledge and do some practical work according to the content of the respective lectures.
- The lectures include interviews in order to provide opportunity to clarify open questions. Since the students are not able to ask questions directly during the lecture (they are able to ask questions via email, though), typical questions are included during the interview episode.

(2) The Learning Platform

The knowledge transfer via learning videos is supported by a demand-oriented guidance concept. This concept adds a large amount of commitment and liability to the relatively impersonal distance learning approach. The support for the students takes place through a learning platform, where information (e.g. dates of the next exam) and further learning material (e.g. PowerPoint slides of the learning videos) are provided and content-related discussions and exchange of ideas can be conducted in forums. Currently, more than 7000 students are registered for participation via this learning platform and up to 2000 students register for an exam each semester (for example January 2018).

(3) Electronic Assessment

In order to overcome the geographical distance to the partner universities and the constant increase in the number of exam registrations, the exams are conducted via electronic assessment. During the exam, the participants in the computer lab of the partner universities are connected with the exam server at the University of Bremen. During this process, IT-security is of great importance. In the computer lab of the partner universities, special secure browsers are used, which deny access to all websites or programs apart from the exam software. Furthermore, the exams are automatically individualized. During these electronic exams of 60 min' duration, 30 questions are randomly chosen out of a question pool for a set of pre-defined chapters. In this way, the probability of creating identical exams is minimized. The questions used in the exam consist of closed answer, choice questions, for example single choice, closed questions, or may take the form of illustrations and diagrams which have to be completed via drag and drop.

In the winter semester of 2017/18, the Virtual Academy provided an exam network with 24 partner universities where exams are periodically conducted. While the Virtual Academy facilitates offering of these courses, student support and the organization and implementation of the examination, there are some requirements for partner universities as well: For the date of the exam, the partner university has to provide a computer lab where the exam can take place and a supervising teacher during the time slot that the exam takes place. Furthermore, there is a coordinator at every partner university who assists with the task to organize the exams and to implement the courses associated with the respective curriculum. The students have the opportunity to choose a suitable exam date at any partner university of the Virtual Academy. After successful completion of the exams, the students will be granted credit points at their respective home-universities.

3.2 Challenges and Developments

Over the past few years, the project experienced some challenges, which led to further developments in the course offerings of the Virtual Academy.

The flexible and innovative online format has proved very appropriate for basic knowledge transfer for large cohorts of students. Learning videos satisfy levels 1 to 3 (knowledge, understanding and transfer) of the shaping skills of sustainable development (de Haan et al. 2008). To satisfy further levels (analyzing, connecting and assessing) additional learning formats are required. One approach is blended-learning seminars, in which learning videos transfer the basic knowledge and a follow-up attendance seminar is then utilized to deepen that knowledge.

Another important issue is to keep the content up to date. Existing online lectures have to be checked and updated and new lectures referring to new sustainability issues and research results have to be produced regularly. The same applies to the technical aspect of the homepage and the learning platform. Both the learning videos and the learning platform have to function on any of the devices of the user's choice. Since sustainability themes like the SDGs are of global interest and the number of international students is increasing, an international strategy has to be developed as well. Therefore, the lectures have to be expanded through incorporation of the results of international research projects. All these challenges and new approaches resulted in the conception of a new learning platform, which considers all the different approaches to use digital media for ESD and provides opportunities to implement new learning technologies.

The new learning platform is based on the concept of research-based learning. Since the 1970s, the concept of research-based learning appeared in different contexts and discussions about higher education didactics. Also, learning and teaching with digital media is part of the *Bologna Reforms* of the European higher education landscape (Dürenberger et al. 2011). According to HUBER (2009) researched-based learning contains the following features:

- Students design their own research process: The essential phases of the research process (development of the research issues and hypotheses, selection of methods, collection of data and verification and presentation of results) are performed in a self-managed style.
- Results of interest to third parties are discovered and published: The discovered results are published freely, so that third parties can use it for further research.
- Team research: Ideally research should be done in (interdisciplinary) teams.
- Phases of reflection: During the research process provision should be made for the phases of reflection and comprehension.

There are some similar concepts, e.g. research-tutored learning, research-led learning or research-oriented learning, but regarding the depth of research results, research-based learning is the strongest of all concepts which have been considered (Fig. 2).

Even though many positive effects are associated with research-based learning, many of these only realize in small projects or very well equipped degree courses with only a few participants (Reinmann 2012). However, the use of digital media could support most of the components of research-based learning and could help to make it accessible to a large number of students. Basic knowledge, methodological knowledge and current research results could be distributed via learning videos, podcasts, blogs or other forms of digital media. Today's students grew up with digital and social media and are experienced in processes to procure information through different channels and engage in online sharing of content such as research results (Reinmann 2012). Digital media provides the infrastructure to exchange content beyond local learning groups and could even involve the international scientific community. It is also conceivable to connect other areas (e.g. businesses) to the research process. Relevant issues for businesses could be announced online, research data could be collected directly from companies and feedback regarding research results could be provided directly.

The concept of researched-based learning combined with the use of digital media has the potential to make an important contribution to ESD. Students can engage

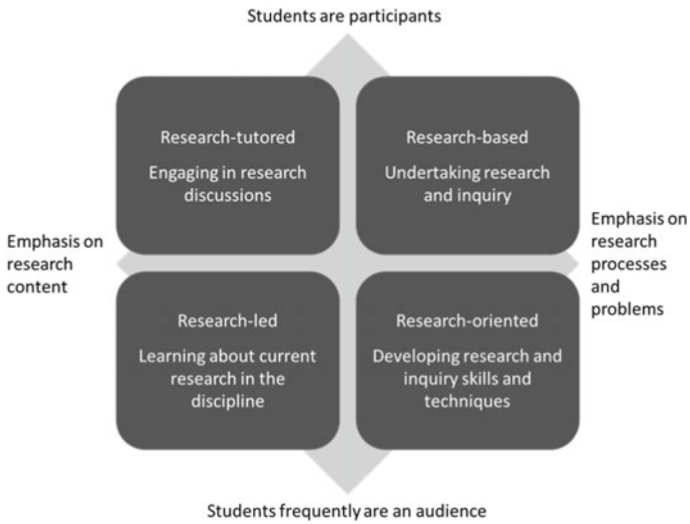

Fig. 2 The research-teaching nexus (own presentation, based on Healey and Jenkins 2009, p. 7)

with current research results on a variety of sustainability aspects, connect these results with their own research questions and thereby add new findings to existing knowledge on sustainability. This enables students to learn how to cope with complex and heterogenic challenges, uncertain information or dilemma situations. The resulting research process is practice-orientated and indicates a shift from knowing to doing. Self-reflection and research-based learning thus connect in a unique way. Self-reflection during action leads to enhanced research questions, while self-reflection during the research process assists with the identification of the best results (Hallitzky 2008). Furthermore, research-based learning requires collaborative working and the exchange of results. Working together (in interdisciplinary teams) can also inspire participants to change their perspectives and to obtain insights about other subject areas.

All characteristics highlighted in the previous paragraph can be regarded as key factors of ESD. To realize ESD through research-based learning concepts, a learning environment has to be created that guarantees access to the following resources:

– basic knowledge and current research results on sustainability themes
– methodological knowledge about research-based learning
– freedom and time to deepen own interests
– open research questions
– networks and opportunities for exchange
– infrastructure to distribute research results.

Pilot projects within a similar setting indicates a synergy between the effectiveness of combining ESD, learning via digital media and creating own content (Brassler et al. 2017). Since the summer semester 2017, the Virtual Academy launched some pilot projects to test the new learning platform, its research-based learning features and associated types of assessment:

– Some courses of the Virtual Academy are now offered in the format of blended-learning or as a combination of videos for basic learning, electronic assessment and tasks performed via the learning platform, for deepening of learning.
– A new way of learning with videos, the concept of social video learning, is integrated with the new learning platform. With a special programmed video player, the students are able to directly comment on the learning videos and discuss the content in real time.
– To implement new media and research-based learning formats, new exercises were integrated with the new learning platform. The students even have the option to create their own learning-videos, to build concept maps and to write about and discuss sustainability topics in blogs.
– For reflection on their own research process as well as that of others, the learning platform includes a system for student peer review. In an anonymous way, the students receive results from other students who worked on other topics and then have to evaluate their contributions. Furthermore, they have to connect the new topic with their own research project and have to reflect on both these research processes.

As a part of the pilot projects an evaluation was conducted and the first results are promising. This included interviews and questionnaire surveys with 700 participants. The students did not experience any problems to handle the different digital media tools, although they experienced some difficulties to work in a more independent, but connected way. Besides getting used to more independency and collaborative work and managing perceived high workloads, the students welcomed the new and different learning tasks, felt more involved in the research and learning process and perceived themselves to be more active.

In the coming years, the offerings of the Virtual Academy will be extended successively until all online lectures meet the expectations of the new approach as presented in this chapter, namely combining research-based learning on sustainable development with digital media.

4 Conclusion

Digital transformation and ESD have much in common: Both are developments with scip-political connections and both are facing challenges in terms of their integration into the higher education system. Moreover, both pose questions about generally accepted teaching concepts and both deal with new ways of teaching and didactical methods. Last but not least, both deal with the themes of social change (e.g. lifelong learning, climate change, internationalization etc.) and search for solutions to face these challenges, with the assistance of higher education. The case study of the Virtual Academy which has been presented in this chapter illustrates that by connecting both these disciplines, larger scale effects in the transformation of the education system can be expected. Therefore, networks could be formed between projects working on ESD and other projects focusing on digitalization and digital transformation.

As presented in the first two parts of this chapter, for the SDGs to be truly successful at a global scale, universities need to champion sustainable development/ESD and play a leading role in the implementation of the SDGs. To achieve this goal within the time frame proposed by the 2030 Agenda for Sustainable Development, a much faster integration of ESD with all facets of higher education is required. In this regard digitalization will and can play an important role, as already experienced in ESD practice. For example, the GAP roadmap states that the successful integration of ESD with higher education requires a rethink in terms of the type of learning environments that are required, whether physical, virtual or online. The case study presented in this chapter shows that research-based learning is an approach which takes the requirements of ESD into account. Furthermore, this case study illustrates that a digital learning environment, designed to meet the principals of research-based learning, can be used to successfully provide high-quality ESD for large groups of students.

Although the results of this case study provide valuable insights, further development and research regarding the creation of online-learning spaces are required. Supplementing resources have to be developed which support competence building and provide enough space for individual and research-based learning. And even if students are familiar with using digital tools, a great challenge is to "educate the educators" on the topics and complexity of sustainable development as well as on using and creating new learning methods and environments.

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Training Competencies for Sustainable Thinking Through an Educational Nature Trail Supported by a Location-Based Smartphone Game

Ulrike Starker, Andrea Heilmann and Dominik Wilhelm

Abstract The goal of this research paper is to train peoples' ability to think sustainably. This includes learning to recognize and handle complex relationships as well as using interconnected thinking to act successfully in the long term. Therefore a theoretical framework for sustainability competency is formulated in this article which is derived from concepts of complex problem solving. For this purpose a training was developed around the topic of "water" to improve these competencies. We chose a "solution-focused" concept which means, learning by positive and inspiring didactical principles. The training is supported by a didactical smartphone-game, involving personal priorities and behaviour. The game is targetted to kids, students and their families, and uses current technological possibilities such as location tracking and augmented reality to enhance the learning experience.

Keywords Sustainable development and teaching · Sustainable competency · Managing complex problems · Emotional adaptivity · Serious games · Game-based learning · Sustainability games

1 Introduction

The 2030 Agenda, which was adopted by the United Nations on 25 September 2015, is a plan of action for people, planet and prosperity. The 17 Sustainable Development Goals (SDG) and 169 targets demonstrate its scale and provide measurable data. Its objectives can be summarized in the following key aspects: the improvement of skills, the efficiency of equal opportunities and the related ecosystem impacts. The

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implementation of sustainability goals requires efforts at the global and local level. When looking at the sustainability goals, it also becomes clear that in many cases a mutual influence takes place and that solution approaches have to consider different perspectives of the actors as well as the complexity of the problems. The topic of "water" is particularly suitable as an example of dealing with complex problems, since the sustainable handling of water is addressed directly (e.g., SDG 6 and SDG 14) as well as indirectly (e.g., SDG 2, 3 and 12). Usage conflicts may occur and people should be able to balance pros and cons to make decisions for complex problems.

Research regarding the handling of complex problems shows that success in handling complex systems is usually dependent on emotional and motivational factors. Failure can mostly be traced back to short term thinking, not regarding possible side effects as well as long-distance effects and overlooking consequences of individual action regarding individual aspects of a situation instead of balancing the goals and other crucial mistakes.

These mistakes (Dörner 2016; Frensch und Funke 2005) can be explained by the fact that people in complex systems oftentimes feel helpless and overwhelmed. Instead of focusing on the problem, they rather take measures which help to restore their feeling of competency. It is easier to concentrate on the things that are easily controllable even if these are not helpful ("encapsulation", Strohschneider 2002) or to initiate "drastic measures" ("overdosage", Dörner 1989) even if cautious procedures would be much more effective.

Research shows, that managing complex problems is a skill that can be trained (Buerschaper et al. 2001). Still the question remains what should be trained specifically and which semantic and didactic preparation is required to reach the target group. Thereby essential approaches for a successful problem-solving process should be considered: stabilisation of self-confidence, an emotional connection to the problem, functional thinking and adjustment of problem-solving strategies.

All these contribute to an emotional stabilisation in the problem solvers and are part of "sustainability competency".

Sustainability competency also means that the reciprocal reinforcement of the components leads to a positive feedback process but it has to be reflected (Tisdale 1998).

Contemporary didactic methodologies such as "game-based learning" can be used to evoke this positive feedback process by simulating a complex system within the space of a game, allowing learners to act on it and perceive the outcomes of their actions. This leads to increased critical thinking, creative problem solving and better learning retention among others (Madani et al. 2017). "Serious Games"—e.g. games designed for purposes other than pure entertainment – have been used in military training, business, healthcare and education contexts among others as their possibility for applied learning allows for deeper reflection and recall. Games let players apply learning contents in a risk-free environment and practice behaviours and problem-solving strategies. By their very nature, games can motivate players to engage with them, thus actively exploring and engaging with learning contents—an approach that can be especially suitable for younger target groups socialized with interactive media. Fabricatore and López (2012) showed, that "…games can indeed provide key conditions and opportunities to foster sustainability learning. When designed with complexity in mind, games are most suitable to promote the development of complex systems thinking and facilitate a systemic understanding of sustainability."

Universities can and must play a pioneering role in the development of sustainability competency, as they train the professionals and business leaders of the future. The topic should be understood as part of the teaching as well as in the context of "Third Mission" as a transfer service of the universities.

In the following, based on research results on the role of emotion during complex problem-solving (Starker 2012), a theoretical framework of "sustainability competency" is presented. Building on this, the methodological approach will be used within a current case study regarding the development of sustainability competency in the field of "water" by using "game-based learning" as an interactive and participatory didactical concept for understanding the correlations in a complex system and practice long-term thinking.

2 Competency for Sustainable Management of Complex Situations

Due to current research (for an overview see Starker 2012), it can be assumed that managing complex problems successfully means to balance natural emotional modulation with emotional regulation in order to have the ability to adapt to the demands of a complex situation. Recapitulating research concerning successful complex problem solving behavior, it turned out, that there are certain abilities and strategies which are connected with success, especially with positive long-term effects. Studies done by Starker (2012) showed, that an important factor is peoples' ability to integrate emotional regulation into the process of problem-solving. According to these studies, a model was developed to integrate four main factors to explain how people are able to act emotionally adaptive.

2.1 Main Factors of the Model

Self-confidence, emotional commitment, functional thinking and adaptation of a strategy are important factors in dealing with complex problems successfully.

Self-confidence is an important pre-condition to engage in problem-solving (Stäudel 1987). It means to believe at least in a minimum of solvability. The "Expectation of success" (Atkinson 1957; Mc Clelland 1951) plays an important role and results from earlier experiences with similar situations. This has relevance for "Self-efficacy" (Bandura 1977), respectively "competency" in sense of Dörner (1989), which turn out to be synonymous constructs. Enduring difficult situations as well as engagement are related to it. Resources can be activated to find solutions. Recognizing and coping with disruptions in difficult circumstances are based on self-confidence. Even in the case of emergency, thoughtful decisions can be made. Self-confidence enables emotional modulation and attachment (Bowlby 1958).

Emotional commitment enables the connection to the problem and realizing the meaning of an individual situation, so that an evaluation of the actual state is possible (Starker 2012). In our research, the emotion-regulating problem solver was emotionally engaged in the problem. E.g. success leads to pleasure and losses to disappointments. In complex problems, where it is difficult to recognize success, emotional commitment can sensitize for the process. The development can be appraised. Also, disruptions can be recognized and reaction tendencies can be developed.

Studies showed that cognitive processes are connected to emotional states. For example light anger is connected to analytical thinking and creative thinking to positive emotions (Bower 1981; Isen 1999; Abele 1995; Hänze 1998). Successful problem-solvers seem to know this and regulate their emotions adequately. Salov-eye and Meyer (1990) mentioned this point in their origin concept of emotional intelligence.

By identifying with the problem, even emotions emerging from complexity, like helplessness, can be controlled. Goal-orientated behavior develops, and pleasure emerges instead of anger. Feedback loops develop and show the way. A person is able to recognize the right time to act and at the same time understand what is missing. The conditions that must exist prior, are motivation and emotional commitment, which are not necessarily typical of normal emotional behavior. This is obvious, when competent problem solvers are able to analyze a situation in the midst of anger. Experience and clarity in understanding one's emotions is necessary to manage this.

Functional thinking: To manage complex problems, it is necessary to develop a mental model about the interrelations between the different aspects of a situation. This allows for the recognition of patterns, which emerge as a situation develops. When one single aspect is changed, what are the consequences? The answer can only be observed after a period of time has passed.

Therefore, it is necessary to conduct interventions and observe what happens. Putz-Osterloh (1983) has pointed out the role that knowledge plays in changing a situation ("Veränderungs-wissen"). In a study done by Starker and von der Weth (2008), a positive effect on performance was shown.

Adaptation of a strategy: One of the conditions for adaptation is having a strategy. Reason (1990) found that experts do not always recognize the necessity of a strategy. This is what makes beginners just as successful as experts in foreign situations (Lesgold et al. 1981; Lesgold 1984). A strategy demands setting goals and realizing them through intentional decision making. You need to know when to do something and how to prioritize. Artelt (2005) and her resource, Craik and Lockhardts (1972), examine different levels of information processing, such as surface strategies and deep strategies.

Applying a strategy can prevent mistakes from happening, because structure provides a better environment for problem-solving. Luchins and Luchins (1942) showed that, in general, routines are used to solve problems, even if they take more effort.

In spite of the assumption that the right strategy leads to the best result, which is relevant in solving easy problems, adapting strategies for individual situations in managing complex problems is central.

2.2 The Theoretical Framework for Developing Sustainability Competency

Learning to solve problems in complex situations becomes a self-reinforcing process that can take different directions. The processes presented above are only a piece of the learning process. The probability of success increases when success occurs, because success breeds success as one reflects on his or her experiences. Through this process, self-confidence grows as well as emotional commitment. This process prepares a person to understand how to cope with complex problems. The factors above are embedded in the process of gaining experiences with complex problem solving (see Fig. 1). Self confidence in combination with emotion regulation leads to an adaptive emotional process, which facilitates certain cognitive processes, like creative or analytical thinking, depending on the problem-solving stage. Using different cognitive directions like bottom-up or top-down thinking, also means adapting the strategy to the situation. If people do this careful reflecting, their advances will lead to success, which increases their confidence. This reciprocal process is needed to develop competency in dealing successfully with complex problems.

Results of a study from Boekaerts (2007) confirm the steps in the cycle of competency gaining. 357 high school pupils documented, in diaries, the level of competency they felt in relation to the effort they put forth, as well as their feelings when they completed their homework in mathematics. The results show that as competency increased, so did the effort. The emotion becomes a mediating variable, because it influences the decision-making process.

Motivation is an important starting point for the problem-solving process. Emotional commitment is required before the problem-solving process can be successful. The person needs to develop a feeling for the situation, e.g. enthusiasm for a certain topic or simply love for nature.

Complex problems often make excessive demands on the psychological system. The disposal of working memory is limited. Normally people only focus on parts of a problem without seeing the big picture. Often, people are too close to a situation and they need to take a step back in order to gain perspective. The vision becomes blurred and results in fear. The synergy of the dynamics of this condition results in impatience and makes a prognosis difficult. This leads to uncertainty and a lack of control. For this reason, emotional regulation is necessary.

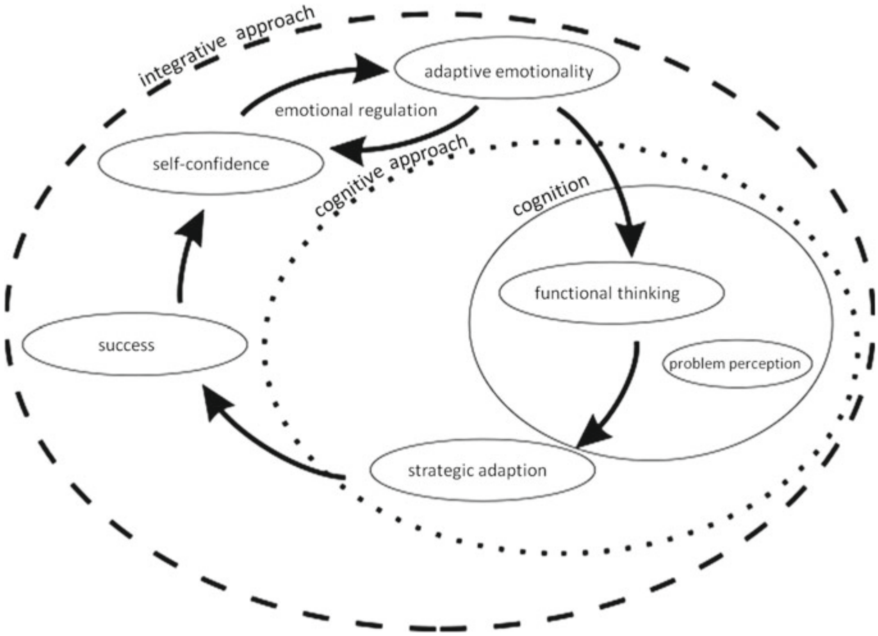

Fig. 1 Developing sustainability competency by dealing with complex problems (Starker 2012)

3 Developing Sustainability Competency with Focus on SDGs

For developing a didactic concept to strengthen sustainability competency, the theoretical model for better problem-solving was used in connection with a project. A topic with a strong emotional connectivity was chosen: water. Water is not only a special chemical element—it is the essence of life. Every human has a high emotional commitment to water. Moreover, water influences almost every area of human being and a number of SDG directly and indirectly.

Water and steam are the air conditioning of the world. Through the density anomaly of the water, enormous "waterfalls" originate from the poles. Those "waterfalls"' drive the sea currents and therefore influence our climate. These processes are also influenced through the increase in the greenhouse effect. Climate changes will have global, regional and personal effects (for example by droughts or floods). Those effects are considered in SDG 13 and in particular in 13.1 which states: "Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries."

Water means life—approximately 80% of the human body consists of water. In order to maintain the human metabolism, approximately 2–3 l of drinking water must be supplied to the body regularly. In addition, we use water for preparing dishes, for hygiene and for washing. The access to drinking water is also addressed in SDG 6.1:

"By 2030, achieve universal and equitable access to safe and affordable drinking water for all." Because of the fact that water is indispensable to life, it needs to be reused. Before returning used water into the water cycle, cleaning is to be guaranteed.

An increasing number of the world's population lives in cities. "In 2015, close to 4 billion people—54% of the world's population—lived in cities and that number is projected to increase to about 5 billion people by 2030." For the realization of SDG 11 ("Make cities and human settlements inclusive, safe, resilient and sustainable") an economized and efficient handling of water must therefore have priority.

Furthermore, water is a means of production in agriculture and industry. The increase of the economic efficiency in this area must accompany the increase of the effectiveness of resource usage, therefore also of water usage (see SDG 12.2 "By 2030, achieve the sustainable management and efficient use of natural resources").

The improvement of the "water footprint" and a decrease of the "virtual water" can serve to clarify global problems. Moreover, both approaches can influence individual purchase decisions significantly.

Nevertheless, the pollution of water resources (ground water and surface water) has to be minimized in order to provide enough water in a sufficient and high quality (see SDG 6.6: "By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes."). In relation to that, economic development has to comply with environmental standards (see SDG 2).

Moreover, water is a natural habitat for many organisms which contribute to a functioning ecosystem. Hence, a further SDG is the preservation of the diversity of species (see SDG 15.5: "Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species."). Intensive use of agriculture or forestry affects this goal.

The topic of "sustainable usage of water" is summed up by Fig. 2 of the SDG. In over 12 of 17 SDG's a relation to water is given, although to different extents.

Reconsidering all mentioned examples of the meaning of water, on the one hand, it is obvious that responsible handling of water as a resource causes emotional commitment for many people. On the other hand, all topics of the SDG are strongly connected with each other, so that the ability of complex problem-solving can be clearly demonstrated on the topic "water". As a function of the experiences and the position of the respective actor, the decisions will be different. However, there is no "right" or "wrong".

A further aspect which can be trained within the usage of waster is the consideration of local acting and global impacts (think global—act local). This can be clarified with the help of the "water footprint": "The water footprint measures the amount of water used to produce each of the goods and services we use. The water footprint looks at both direct and indirect water use of a process, product, company or sector and includes water consumption and pollution throughout the full production cycle, from the supply chain to the end user.[1] Once the water consumption is visible for the end user, buying decisions can depend on it.

[1] http://waterfootprint.org/en/water-footprint/what-is-water-footprint.

Fig. 2 Analysis of the SDG in relation to the topic water (blue-framed) (UN)

The analysis of the complex interrelations of the topic water has been used in a research project. Within this project, a didactic concept was developed to strengthen sustainability competency based on the concept of complex problem-solving.

4 The Research Project: Case Study "Smart in the Harz Mountains"

The didactic concept should be adjusted to the regional specifications. This means the complex and linked aspects of sustainable water use should be embedded in the regional environment. The Harz region in Saxony-Anhalt advertises with "Pure Nature—Beautiful intoxicating wilderness: Rugged granite cliffs, mountain pines, misty moors and deep valleys with babbling brooks" are some of the characteristics of this region."[2] Here, water plays an important role. An emotional connection is activated through the beauty and variety of the nature as well as through the flora and fauna in and around the water.

As a possible result of climate change, more frequent extreme precipitation caused floods and damages in recent years. Through rising temperatures, a spread of various species can be recognized, for example the bark beetle as well as the appearance and spreading of invasive species. Negative effects on forestry and tourism are the results. Consequentially, the water retention of damaged woods is lower, which in turn has effects on flood control. Although the results of climate change are present and visible in the region, personal habits are rarely associated with an improvement of resource efficiency (or even the issue of water usage).

[2] http://en.harzinfo.de/pure-nature.html.

A gulp of spring water is a pleasure and drinking from mountain streams is absolutely possible in the area. One can enjoy the water without hesitation. There are many natural mineral springs in the Harz region. The natural springs, which have their origin in protected wood areas like the National Park Harz, flow into the dam system of the Rappbode dam and are refined to drinking water in waterworks.

The reservoirs are not only used for supplying drinking water, but they also play an important role in flood control and energy supply. Nevertheless, the preservation of this high-quality raw material—water—leads to a partial restriction in land, forest and touristic use in the region. The interdependency between the loss of nature and the use for flood control and climate-friendly energy generation becomes clear in this topic. Beside reservoirs, mountain streams can be used for energy generation by the application of waterwheels. In order to protect fish and their natural passages a fish ascent and descent system is necessary.

All those different subjects are connected in an interactive educational nature trail. This path considers the necessary points of departures for a successful problem-solving process to develop sustainability competency. The following table sums up all topics and their interactions, which are represented in the single stations of the nature trail:

An emotional commitment is aimed at through the selection of the topics. This occurs in special measures by using various personal points of contact with water which lead to very personal attitudes.

Functional thinking consists of the fact that a situation is analyzed with regard to its action variables. This happens on the basis of the question about the consequences. In the center are the relations between the variables of a system. Considering the example of water usage the different effects of decisions can be clarified. For example, intensive agricultural or industrial use can be harmful to the resource "drinking water" in the long-term. Moreover, the decrease of the storage capacity of the ground can require additional measures of flood control.

Strategic adaptations are also needed concerning the sustainable handling of water. For instance, with progressing climate change, new requirements for the management of water, for nature conservation and flood control become necessary.

The transfer of the topic in Table 1 is supported by a digital game which can be played while walking the nature trail. The game fosters understanding of the correlations between elements in a complex system, allows players to practice the strategic management of resources and provides feedback about the short- and long-term effects of their decisions. Also, solving complex and linked problems through a playful challenge supports building up and strengthening the confidence of the actors.

The game will be available as an application for smartphones. Hence it will use modern digital possibilities to attract the target group of kids, students and their families who are walking the nature trail together (Individually or as a team). However the game can be adapted to different target groups.

During the course of the game, the player collects drop-shaped characters called "Droppy", which can be discovered based on the location of the player on the aforementioned nature trail. Each drop represents a different function of water, for example

Table 1 Topics of the educational nature trail for developing sustainability competency

Topic	Addressing of emotional/multisensory aspects	Related topics/conflicts
Flora and fauna in and around water	**Touching**: own observations (e.g. with magnifying glass) **Hearing**: forest noises personal questions	Self-cleaning of waters, influence on drinking water quality
	Smelling: smell of moss and plants information	Recovery and tourism, meaning in the ecosystem forest, healing effects
	Seeing: pictures from the forest with and without bark beetle	Climate protection (also related to the water footprint) and adaptation, tourism
Flood	Pictures and personal experience reports	Climate protection and adaptation, forest as water tank, civil protection
Energy generation	**Touching/trying**: producing water power	Nature conservation, intervention in the landscape or waters
Drinking water	**Tasting**: tasting, comparison of different waters	Expenditure of the processing of drinking water, transports of mineral water

biodiversity or energy generation (Fig. 3). Furthermore, each drop can be in a different mood, depending on the current status of its function, which is shown in Fig. 4. The goal of the game is to make all drops happy. By scanning marker-graphics, which are placed on each station of the trail, with his smartphone, the player can collect new “Droppy” characters in the digital game. Using augmented reality (AR) technology, these characters can be seen as emerging from the marker-graphic and seemingly “coming to life” inside the actual natural scenery when observed through the lens of the smartphone-screen. The player can thus uncover a hidden world at the stations of the nature trail and interact with it. Each newly collected “Droppy” confronts the player with a new question or task, with different solutions or answering possibilities. Every decision the player chooses, influences other drops and makes them either more satisfied or dissatisfied. However, there are no “right” or “wrong” answers in this game. The player has to recognize interdependencies, set personal priorities and operate flexibly to create an ecosystem of equally happy “Droppys”.

The nature trail as well as the game are to be completed within the next year, in close cooperation between students, water authorities and the local tourism office.

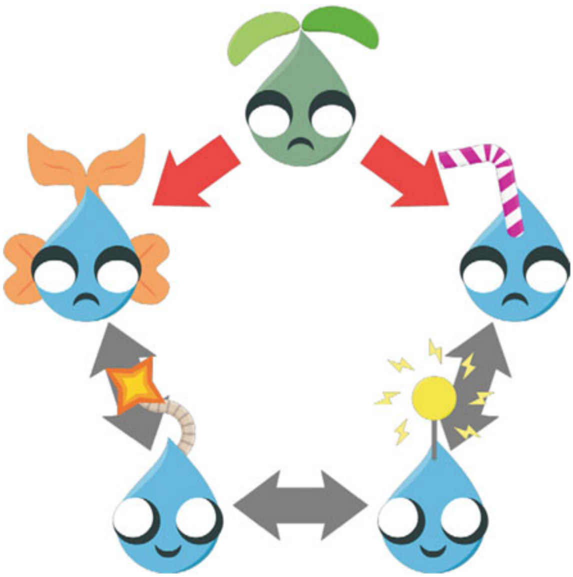

Fig. 3 Different types of “Droppy” (depending on their activities, such as biodiversity, drinking water, energy generation, risks and dangers, fauna) influence the mood of their neighbors (Brinkmann 2018)

Fig. 4 Different states of “Droppy” depending on their mood (sick, dissatisfied, satisfied, happy, enthusiastic) (Brinkmann 2018)

5 Conclusion and Outlook

Based on a review of literature, 4 key elements have been identified as crucial for the development of sustainability competencies and summarized in an integrative model:

- Self-confidence
- Emotional commitment
- Functional thinking
- Adaptation of strategy.

This integrative model was adapted to a training concept which has been developed on the topic of “sustainable usage of water as a resource”—a topic which is especially suited to the development of sustainability competencies, as it has various connections to the SDGs, as well as regional and trans-regional issues.

Different objectives of sustainable water usage can influence each other in positive or negative ways. To explore the interconnectedness of these aspects, a case study has been developed, based on the concept of an educational nature trail supported by a digital game which integrates virtual characters into the natural landscape through the lens of the players' smartphone. The game allows for interactive exploration of sustainability issues discussed in the educational signage of the trail. This opens up the players to discover the manifold relationships between the objectives of sustainable water usage. Players can apply and strengthen what they learned on the trail, while gaining awareness for the short- and long-term repercussions of ones' actions within the parameters of a complex system by taking playful actions and experiencing the consequences of these actions, yet all in the "safe", virtual environment of the game.

The model for developing a concept for the educational nature trail and the digital game was applied from an interdisciplinary team of students, lecturers of water economy, business psychology and applied game design. The concept was also discussed with other actors from different sectors.

In the future, the following milestones have to be realized:

- implementation of the stations of the path and further development the game
- on-location testing and refinement of the games' system, graphics and code
- development of a concept/measurement for sustainability competencies
- development of a training and education concept for students and external actors.

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Upcycling for Teaching and Learning in Higher Education: Literature Review

Kyungeun Sung

Abstract Upcycling is creation or modification of any product from used materials, components and products which is of equal or higher quality or value than the compositional elements. Upcycling, in principle, increases material efficiency, reduces waste, energy consumption and greenhouse gas emissions, and creates employment opportunities. When scaled up to a meaningful level, it could, in theory, contribute significantly to achieving multiple Sustainable Development Goals (SDGs). For such potential benefits, upcycling has been practiced in households and businesses, and existing studies have reported on these cases. Relatively little attention has been paid to how universities have utilised upcycling for teaching and learning activities. This paper therefore aims to provide a literature review on the use of upcycling for and in higher education. Systematic literature review was conducted. The results present how upcycling concept and practice have been used as contents, media or tools for teaching sustainability and sustainable practices at universities across countries. This paper extends our understanding of upcycling in the context of higher education for sustainability. The practical implication is that any future university initiatives relating to SDGs could be informed about the applicability and usefulness of upcycling in their initiatives.

Keywords Higher education · Sustainable development · Teaching and learning · Upcycling

1 Introduction

Upcycling is creation or modification of any product from used materials, components and products which is of equal or higher quality or value than the compositional elements (Sung et al. 2014; Sung 2017). It is an umbrella concept which incorporates 'creative' reuse, repair, refurbishment, upgrade and more (Sung et al. 2017a, b).

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Upcycling is both a form of alternative consumption in which consumers can engage (Albinsson and Yasanthi Perera 2012), and a form of alternative production that environmentally conscious entrepreneurs can utilise (e.g. Sung and Cooper 2015). Within the context of increased product longevity (Cooper 2010), it enables a reduction in the use of raw materials by extending the lifetime of used materials, components and products, thereby increasing material efficiency and reducing industrial energy consumption (Allwood et al. 2011). The reduction in energy consumption contributes ultimately to lowering greenhouse gas emissions (Hamit-Haggar 2012). It also reduces solid waste or, at least, delays new addition of waste to landfill (Bramston and Maycroft 2013). The benefit of upcycling is not limited to lessening negative impact on the environment. Businesses based on upcycling can create employment opportunities especially for the disadvantaged people (Campbell 2017; Gelbmann and Hammerl 2015; Guerrini 2014). Upcycling as a hobby could contribute to individuals' psychological wellbeing by providing experience benefits (i.e. upcycling process as a meaningful journey and learning experience), empowerment benefits (i.e. becoming more capable and self-reliant), a sense of a community through upcycling networks if any, and reducing stress and relaxing (Frank 2013; Gauntlett 2011; Lang 2013; Sung 2015). When scaled up (Van den Bosch 2010) to a meaningful level, it could, in theory, contribute significantly to achieving multiple Sustainable Development Goals (SDGs): e.g. promote well-being, promote lifelong learning opportunities, promote sustained, inclusive and sustainable economic growth, ensure sustainable consumption and production patterns, take urgent action to combat climate change and its impacts (United Nations General Assembly 2015). For such potential benefits, upcycling has been practiced in households and businesses, and existing studies have reported on these cases (e.g. Janigo et al. 2017; Sung et al. 2017a, b; Sung and Cooper 2015; Wilson and Wilson 2016). Relatively little attention has been paid to how universities have utilised upcycling for teaching and learning activities. This paper therefore aims to provide a literature review on the use of upcycling for and in higher education.

2 Methods

A systematic literature review (Fink 2013) was conducted between November 2017 and January 2018. Research questions were generated. Bibliographic databases were selected. Practical screening criteria were applied. Selected pieces of literature were reviewed and results were synthesised.

2.1 Research Questions

Research questions were: (a) who have been publishing papers on upcycling for and in higher education? (e.g. occupation, affiliation); (b) when was the paper published?;

(c) where (journal, country and region) was the paper published?; (d) in each paper, what is discussed or used regarding upcycling in the context of higher education? (e.g. concept or practice of upcycling); (e) in each discussion/activity/etc., how is upcycling utilised?; and (f) what is the rationale behind (or reason for) the use of upcycling?

2.2 Bibliographic Databases

Acknowledging the relative newness of the term, upcycling (Sung 2015), a variety of major digital academic databases were selected for search. They were Elsevier, Emerald, IEEE, Taylor & Francis, and Web of Science.

2.3 Search Terms and First Screening

The following search keyword combinations were used to identify literature: (a) “upcycling” AND “higher education” AND “teaching”; (b) “upcycling” AND “higher education” AND “learning”; (c) “upcycling” AND “university” AND “teaching”; (d) “upcycling” AND “university” AND “learning”; (e) “upcycle” AND “higher education” AND “teaching”; (f) “upcycle” AND “higher education” AND “learning”; (g) “upcycle” AND “university” AND “teaching”; and (h) “upcycle” AND “university” AND “learning”. Only English publications were considered for selection. The selection was focused upon journal articles, conference proceedings, academic books and book chapters, Ph.D. theses and research institute reports.

2.4 Initial Search Results and Second Screening

Initial search yielded a total of 250 results from the five databases. After removing duplicate results, 130 pieces of literature remained. These 130 articles were examined to assess the content relevance, mainly by qualitative analysis of titles and abstracts. For example, the journal article, “Solutions for global marine litter pollution,” was one of the search results since the paper suggests upcycling as one of the solutions and it contains a box story about massive open online course for learning on marine litter. By reading the title and abstract thoroughly and critically, however, it was apparent that the paper does not address upcycling in the context of learning and teaching in higher education. This process resulted in seven relevant pieces of literature. These seven publications were used for both descriptive analysis and synthesis of the results.

3 Results

The following sub-sections first describe trends in publication, answering the questions on: (a) who have been publishing papers?; (b) when was the paper published?; and (c) where was the paper published? (see *Research Questions*). They then present the synthesis of the results on how upcycling concept/practice was utilised for what reason, answering (d) to (f) questions. See Table 1 for the list of reviewed publications and Table 2 for the summary of use of upcycling for and in higher education.

3.1 Who: Authors of the Publications

The authors (n = 21) of the publications were mostly professors (nine full professors, three associate professors and three assistant professors). Three were researchers (one Ph.D. student, one associate researcher and one senior research fellow). Others were one coordinator (of sustainability and higher education), one educational developer and one scientific programmes senior expert. The affiliations of most authors (n = 20) were universities; one exception was The Scientific and Technological Research Council of Turkey. Within universities, the authors' departments were business management (n = 6), design (4), multidisciplinary centres for sustainability (3), natural science and engineering (3), education (2) or others (communication and psychology, advanced studies).

3.2 When and Where: Years of Publication, Journals and Geographical Locations of the Authors

All seven articles were published between 2014 and 2018. They were published in journals related to design (n = 3; two fashion and one general design), education (2), sustainability (1) and future (1). In terms of geographical locations of the authors, the majority of the authors were based in Europe (n = 13) including Austria, Belgium, Denmark, Germany, Turkey and the UK. There were four authors from Middle East (Iran), three authors from North America (USA) and one author from East Asia (South Korea).

3.3 What and How: Use of Upcycling and Its Context

Upcycling was used as a concept (n = 5) and/or a practice (4) in the context of higher education. When upcycling was used as a concept, three articles referred to the seminal work by Braungart and McDonough (2002, 2013) advocating a cradle-

Table 1 List of reviewed publications (in alphabetical order of authors' surnames)

No.	Authors	Year of publication	Title	Journal
1	Beynaghi A., Moztarzadeh F., Maknoon R., Waas T., Mozafari M., Hugé J. and Leal Filho W.	2014	Towards an orientation of higher education in the post Rio+ 20 process: How is the game changing?	Futures
2	Dharmasasmita A., Puntha H. and Molthan-Hill P.	2017	Practical challenges and digital learning: getting the balance right for future-thinking	On the Horizon
3	Kılkış Ş. and Kılkış B.	2017	Integrated circular economy and education model to address aspects of an energy-water-food nexus in a dairy facility and local contexts	Journal of Cleaner Production
4	Lee Y.K. and DeLong M.	2018	Rebirth Product Development for Sustainable Apparel Design Practice in a Design Studio Class	Fashion Practice
5	Leube M. and Walcher D.	2017	Designing for the next (Circular) Economy. An appeal to renew the Curricula of Design Schools	The Design Journal
6	Park J.	2014	Upcycled parachutes project at Colorado State University	Fashion Practice
7	Robinson S., Neergaard H., Tanggaard L. and Krueger N.F.	2016	New horizons in entrepreneurship education: from teacher-led to student-centered learning	Education + Training

Table 2 Summary of use of upcycling for and in higher education (in alphabetical order of authors' surnames)

No.	Publication	Use of upcycling for and in higher education
1	Beynaghi A., Moztarzadeh F., Maknoon R., Waas T., Mozafari M., Hugé J., and Leal Filho W. (2014). "Towards an orientation of higher education in the post rio 20 process: How is the game changing?". Futures, 63, 49–67	A concept of upcycling, referring to "The Upcycle: Beyond Sustainability—designing for abundance" (McDonough and Braungart 2013), was used as a weak signal to indicate that the sustainable development (SD) concept is currently in transition from sustainability to a new phase, "post sustainability," in explaining the evolution of the nexus between SD and higher education.
2	Dharmasasmita A., Puntha H., and Molthan-Hill P. (2017). "Practical challenges and digital learning: Getting the balance right for future-thinking". On the Horizon, 25, 1, 33–44	A general practice of upcycling was suggested as one of new hands-on activities for Sustainability Challenge Days (incorporating individual certificate completion, group discussion and practical activities promoting sustainability) as part of Sustainability in Practice Certificate programme at Nottingham Trent University (initiated by NTU's Green Academy) in order to teach students the concept and practices of sustainability in support of sustainable development.
3	Kılkış Ş, and Kılkış B. (2017). "Integrated circular economy and education model to address aspects of an energy-water-food nexus in a dairy facility and local contexts". Journal of Cleaner Production, 167, 1084–1098	A concept of upcycling, referring to the seminal work by McDonough and Braungart (2002), was used as part of environmental education contents to show solutions or frameworks to enable sustainability within an energy policy module/course in order, ultimately, to facilitate transition in society towards realising more sustainable energy, water and environmental systems.
4	Lee Y. K., and DeLong M. (2018). "Rebirth product development for sustainable apparel design practice in a design studio class". Fashion Practice, 1–19	A concept of upcycling in fashion was used interchangeably with 'rebirth design'—redesign of stock items (unsold and returned products) to new saleable products. A practice of fashion upcycling (or rebirth design) was utilised for a collaborative design process within an education-industry partnership. It was for students to have the opportunities to experience sustainable fashion design and remanufacture practice in industry, and for companies to prevent the wasteful disposal of unsold products and to save money (by decreasing maintenance fees for warehouses and managers to maintain the value of stocked products).

(continued)

Table 2 (continued)

No.	Publication	Use of upcycling for and in higher education
5	Leube M., and Walcher D. (2017). "Designing for the next (circular) economy. An appeal to renew the curricula of design schools". The Design Journal, 20, S492–S501	A concept of upcycling (synonymous with a cradle-to-cradle approach suggested by Braungart and McDonough 2002) was used as a content and general approach applied to design education curricula for designing for a circular economy (CE). Upcycling was selected since it is one of the most effective and rigorous approaches for sustainable design and it stands at the centre of CE. Incorporating CE principles including upcycling into design education was viewed as a disruptive innovation through radical curricula change for a transition towards CE.
6	Park J. (2014). "Upcycled parachutes project at Colorado State University. Fashion Practice, 6, 1, 119–124	Fashion upcycling practice was used for a collaborative product development project between a non-profit organisation (Aspen Pointe) and a university (Department of Design and Merchandising at Colorado State University) to develop new marketable products by reusing military parachutes and wool, providing entrepreneur solutions for disabled and disadvantaged veterans and their families. The project aimed to offer students an innovative learning opportunity in sustainability with a real-life scenario.
7	Robinson S., Neergaard H., Tanggaard L., and Krueger N. F. (2016). "New horizons in entrepreneurship education: From teacher-led to student-centered learning". Education Training, 58, 7/8, 661–683	A concept of upcycling (as a sub-category of bricolage – accumulating odds and ends, and recombining existing and discarded resources for new purposes) was used as one of the approaches to promoting entrepreneurial awareness and mind-set in the context of entrepreneurship. A practice of upcycling (constructing a product from waste materials) was utilised as a group assignment to practice bricolage since entrepreneurs are often faced with a lack of resources and have to make do with what is at hand. By practicing upcycling, students learned how to embrace resource constraints, ignore barriers, and actively engage with problems in the shape of improvisation.

to-cradle approach to design, business, production, consumption and lifestyles—e.g. aluminium keeps its potential endless high value cycle. In this context, upcycling is a synonym of an act based on a cradle-to-cradle approach or principles which eliminates the concept of waste by reutilising used or discarded materials for multiple cycles. Beynaghi et al. (2014) regarded Braungart and McDonough's latest book "The Upcycle: Beyond Sustainability—designing for abundance" (2013) as a weak signal to indicate that the sustainable development concept is currently in transition to post sustainability in explaining the evolution of the nexus between sustainable development and higher education. Kılkış and Kılkış (2017) suggested upcycling (cradle-to-cradle act) as part of environmental education contents to show solutions or frameworks to enable sustainability within a module/course in energy policy. Leube and Walcher (2017) utilised upcycling as a content and general approach applied to education curricula for designing for a circular economy in the department of design and product management. In Lee and DeLong's article (2018), upcycling was used as an interchangeable term with 'rebirth design'—redesign of stock items (unsold and returned products) to new saleable products in fashion. Robinson et al. (2016) used upcycling as a sub-category of bricolage—accumulating odds and ends and recombining existing and discarded resources for new purposes—in the context of entrepreneurship.

When upcycling was used as a practice, two articles described how fashion upcycling practice was used for a collaborative design process between students and external organisations (company or charity) in student projects. Lee and DeLong (2018) involved one fashion company that provided items of stock from various brands to apparel students in fashion design school such that the students could be involved in the process of redesign, refinement, remanufacturing and consumer study (preference test for upcycled clothes). Park (2014) documented a collaborative product development project between a non-profit organisation and a university to develop new marketable products by reusing military parachutes and wool so as to provide entrepreneur solutions for disabled and disadvantaged veterans and their families. Another article described how general upcycling practice could be used for teaching sustainability: Dharmasasmita et al. (2017) suggested upcycling as one of new activities for Sustainable Challenge Days (university level sustainability initiative). In an entrepreneurship module/course, Robinson et al. (2016) gave students a group assignment of constructing a product from waste materials as a practice of bricolage.

3.4 Why: Why Upcycling for and in Higher Education

Three papers reported the cases that upcycling was used as means to the end, contributing to sustainable development. Kılkış and Kılkış (2017), in energy policy, utilised upcycling as part of educational contents as they believe that a transition in the education system is a prerequisite for enabling a transition in society towards realising more sustainable energy, water and environmental systems. Similarly, Leube and Walcher (2017) incorporated principles of circular economy (CE)—an economy that turns goods at the end of their service life into resources for others, closing loops in industrial ecosystems (Stahel 2016)—including upcycling into design education as they are convinced that designing for CE requires disruptive innovations starting from design schools with radical curriculum change. Dharmasasmita et al. (2017) suggested upcycling as one of potential new activities for Sustainable Challenge Days which have been run as part of Sustainability in Practice Certificate initiative in the university in order to teach the concept and practices of sustainability in support of sustainable development.

Two articles reported the cases that upcycling was used to teach sustainable practice in fashion and product design. Lee and DeLong (2018) pointed out the issue of Korean fashion industry's stock increase and hence high maintenance fees for warehouses and managers as well as wasteful disposal of unsold products. Fashion upcycling was therefore used for the university-industry collaboration project to provide participating students with the opportunities to experience sustainable fashion design and remanufacture in industry, while helping the partner company to reduce their cost and waste. In Park's case (2014), the collaborative product development project based on upcycling (in order to offer comprehensive career and development services for the military community) aimed to offer students (in the department of design and merchandising) an innovative learning opportunity in sustainability with a real-life scenario.

One article described the case that upcycling was used to teach entrepreneur awareness and mind-set to students in an entrepreneurship module/course because entrepreneurs are often faced with a lack of resources and have to make do with what is at hand (i.e. the materials available cheaply or for free) (Robinson et al. 2016). Upcycling (or bricolage) as a group assignment taught students how to embrace resource constraints, ignore barriers and actively engage with problems by improvising.

4 Conclusions

Most articles were published by academic staff members in universities predominantly from the areas of business management, design, sustainability and engineering, which may imply that these areas are relatively more pertinent than others for utilising upcycling for and in higher education. All seven articles were published between 2014 and 2018, which confirms that research on upcycling for and in higher education is in its infant stage. This new area of research has been explored chiefly by European researchers, which may mean European higher education institutions' collective, stronger emphasis on embedding sustainability (or contributing to Sustainable Development Goals). In each publication, upcycling was used as a concept and/or a practice. When using upcycling as a concept, the articles frequently referred to the seminal work by Braungart and McDonough. It was interchangeably used with 'rebirth design' in fashion and with bricolage in entrepreneurship. The concept of upcycling was used as educational contents (i.e. solutions or frameworks for or general approach to a circular economy or transition towards more sustainable future). When used as a practice, upcycling was utilised for two university-industry collaboration projects (fashion and product design), one potential hands-on activity as part of university-wide sustainability certificate initiative, and one group assignment for entrepreneurship module/course to practice bricolage. The main reason for utilising upcycling (concept or practice) was to contribute to sustainable development or to teach sustainable practice in particular disciplines.

This paper, despite the small number of reviewed articles, extended our understanding of upcycling in the context of higher education for sustainability through systematic literature review, informing about how upcycling concept/practice has been utilised in different context and for varied purposes with the main, ultimate goal to achieve sustainability. It is the author's hope that anyone who is involved in future university initiatives at different levels (e.g. module/course, programme, school) aiming to contribute to Sustainable Development Goals will find this paper inspirational and informative to develop their own.

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Sustainability Practices: The Role of University in Forming Master Students' Perspectives

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Abstract The purpose of this research is to analyze master students' perspectives on determinants of sustainable education and practice at Universities. This is significant as Institutions of higher education have the role of training future managers and, above all, citizens conscious of their role in society. This paper presents the outcome of a master of business advanced topics lecture, where students and professor held discussions on the sustainable university. The study is qualitative, descriptive, exploratory and cross-sectional, carried out with 18 students from the Graduate Program in Business at a university in southern Brazil. Research methods include participant observation and document analysis. An analysis of the materials produced during the lecture leads to the conclusion that students' knowledge evolves to incorporate environmental, social and economic aspects of the sustainable development concept. Students developed short and long-term action plans for implementation at the University and indicators from which HEI may track the development of sustainable practices. These results exemplify how students' understanding about the importance of involving all spheres of the University and community in the sustainability debate can be raised.

Keywords Education · Sustainable development · Business students · Perceptions of sustainability · Sustainable learning

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1 Introduction

Academic discourse on sustainability in general and sustainability in higher education in particular began as a response to social demand. This demand is reflected in the current urgency to train new professionals to work with problems related to sustainable development. To address this demand universities are increasingly called upon to play a leading role in developing forms of interdisciplinary education geared to finding solutions to current challenges.

The historical record shows that universities play a key role in the development of society (Alonso-Almeida et al. 2014). This includes their potential to educate and sensitize our future leaders and managers to issues related to sustainable development (Ceulemans et al. 2015b). These institutions are challenged to promote the sustainable development of their administrative and academic functions, with the solid, active participation of their managers, teachers and students. For Alonso-Almeida et al. (2014), in this regard universities have two missions: to provide students with new skills to create a more sustainable society and reduce the environmental impact of their operations.

Consequently, the university must reflect on whether its management and teaching-learning spaces support sustainable development strategies in HEI. To make it possible, decisions are taken by universities managers, which one can support the idea that they alone comprehend and develop the way towards sustainability. However, looking in the medium and long term, some of current students will be the university managers and we should understand how they perceive HEI sustainability. With this in mind, in this study we discuss the understanding of a sustainable university from the perspective of postgraduate students in a University located in Brazil. We then discuss their opinions on the motivating and inhibiting variables for the development of a culture of sustainability in the university. This debate identifies current difficulties students realize and, based on students perceptions, suggests improvements universities should implement to become more sustainable. We expect these views can support universities today to employ better course of action.

2 Theoretical Background

It is undeniable that economic development has brought profound changes to people's lives, bringing them access to various new technologies and facilities. However, these transformations have been accompanied by numerous problems such as climate imbalances, the latent possibility of depletion of natural resources, the generation of vast amounts of waste with no appropriate destination or reuse, the exponential increase of the human population, poverty and poor distribution of resources.

Under these conditions, where the continuous exploitation of resources becomes unsustainable, a series of concerns have been raised in the quest to better understand current contingencies and to establish alternative solutions and proposals which take into account the quality of life of future generations (Lozano 2014). For this reason, discourse on sustainable development has grown in recent decades. This discourse aims to identify ways to maintain the long-term viability of the relationship between society and the environment.

The evolution of the concept of sustainable development has progressed in the last decades, from its preliminary form of referring simply to the preservation of natural resources, to a broader meaning involving a long-term vision. For Leal Filho et al. (2009), in general, sustainability

- Refers to long-term prospects with ecological, political, economic and social implications;
- Is a dynamic process whose implementation depends on the due consideration of social processes, and of which individual involvement and participation are essential elements;
- Depends on joint efforts and cannot be based solely on actions of some countries or local actors but should be deployed on the global level.

From this we can infer that it is necessary to emphasize the role of education in promoting sustainable development in the international debate on sustainability (Leal Filho et al. 2009). Therefore, universities have been called upon to study the topic, since HEIs are responsible for educating and training the professionals who will manage and work in the various organizations that constitute society (Lozano 2014). In addition, universities play a key role in setting an example, so the challenge is to incorporate sustainability into the practices followed and developed by HEIs. By putting theory into practice HEIs help ensure that the concept of sustainability becomes real to and is incorporated and perceived by teachers, students and the community of which the institution is a member. That is, what characterizes a sustainable university, is an institution that offers both a critical reflection on society and a democratic experience while remaining in direct contact with the community where it is located. It is imperative that the HEI remain tuned to the demands of that community in order to contribute to its development (Ceulemans 2015a).

In addition, for Nejati and Nejati (2013) a sustainable university can be defined as a university that, in addition to the quest for academic excellence, tries to insert values into people's lives which promote sustainable practices in teaching, research, community management, waste management, land use management and the ongoing planning and monitoring of the commitment to sustainability. In this way, a university is sustainable when it applies sustainability criteria to each of its traditional teaching, research and extension functions (Souza 2016). In addition, the management of HEI should be concerned with incorporating environmental issues into waste management, water and energy consumption and conscious purchasing, for example. However, according to Dias et al. (2013), this process is far from being realized.

Lozano (2014) concurs, finding that sustainable development actions developed by HEIs are compartmentalized and are not holistically integrated in all HEIs. The HEI can institute multiple practices but if they are individualized and are not integrated, they do not end up producing a culture of sustainability that transforms the whole of the University, its physical space, curricular orientation and practice in research. Lozano (2014) also suggests that there is a strong relationship between the commitment of HEIs to develop sustainability practices and the signing of international declarations. These agreements arose precisely from the challenge of integrating the multiplicity of local practices on a global scale. They aim to promote effective change through greater involvement of HEIs. They include:

- The 1990 Declaration of Talloires, France, which includes a ten-point action plan to incorporate environmental sustainability into teaching, research, extension activities and operations in colleges and universities (Alshuwaikhat and Abubakar 2008).
- The 1991 Halifax Declaration, Canada, which provides an action plan for practical strategies to implement sustainable development in universities (Cruz López 2008) and emphasizes the importance of interdisciplinary work for education and research, with a proactive approach to achieve the goals of sustainable development.
- The 1993 Declaration of Swansea, Wales, which induces universities to seek, establish and disseminate a clear understanding of sustainable development, strengthening universities' capacity to teach sustainable development principles, increase the availability of information on it and strengthen environmental ethics (Cruz López 2008).

In addition, the 1993 Kyoto Declaration (Japan), held during the ninth round of the International Association of Universities (IAU) (Cruz López 2008), increased interest in campus sustainability, forcing educational institutions to promote the education of sustainability by reviewing their operations to develop best practices for sustainable development (Faghihi et al. 2015).

With Agenda 21 held at the Rio Summit in 1992 (Lozano et al. 2013b), the role of universities in improving environmental conditions is recognized because they provide the basis of knowledge and professional development, from which the opinions and personality of future managers are formed.

Still, among the most important statements that address the education of sustainable development is that made in 2001 in Lüneburg, Germany. (Alonso-Almeida et al. 2014). It promotes the development of Agenda 21 within academia, seeking to form a united front with it to face the challenges of sustainable development. At the 2002 "Rio+10" Earth Summit in Johannesburg, South Africa, the concept of education for sustainable development was created by establishing Ubuntu Education, Science and Technology for Sustainable Development (Cruz López 2008). In December of that year the General Assembly of the United Nations adopted a resolution to establish the United Nations Decade for Education for Sustainable Development between 2005 and 2014 (Alonso-Almeida et al. 2014). In this resolution, the concept of sustainability development was described according to fifteen strategic perspectives. They are indicated in Table 1.

Although according to Alonso-Almeida et al. (2014) the deadline has been exhausted, the diffusion of the sustainability report is still at an early stage in universities. No massive diffusion is expected based on current data, despite growing concerns about sustainability among young people and other university stakeholders. The author stresses that some actions must be taken to persuade universities to

Table 1 Strategic perspectives to inform education and learning for sustainable development—UNESCO (2005)

Socio-cultural perspectives	Human rights
	Peace and human security
	Gender equality
	Cultural diversity and intercultural understanding
	Health
	HIV/AIDS
	Governance
Environmental perspectives	Natural resources (water, energy, agriculture, biodiversity)
	Climate change
	Rural development
	Sustainable urbanisation
	Disaster prevention and mitigation
Economic perspectives	Poverty reduction
	Corporate responsibility and accountability
	Market economy

Souce UNESCO (2005)

adopt the standards set out in the reports, highlighting their benefits to the HEI and to society.

The connections among these perspectives should serve as information for education and learning of sustainable development. However, a major difficulty encountered when promoting this type of practice is the lack of tradition and established habits, reflected in a strong resistance to change (Lozano et al. 2013a). Therefore, reform must involve discussion between teachers, employees students and the university community at large which results in a change of culture. That is, a change in the day to day lifestyle, habits and environmental perception of each stakeholder (Dyball et al. 2015).

Alternatively students can be training in sustainability from a flexible curriculum focused on solving problems and studying the environment through the use of well-established educational techniques. Building on this, Lozano (2014) reports that the evolution towards more sustainable societies implies that we move from reactive responses of immediate problems to a more proactive approach on how to avoid possible future problems and prepare for potential eventualities. That is, real problems can be transformed into learning laboratories, where new theories, methodologies and tools are developed that challenge the status quo in order to solve today's problems with tomorrow's ideas. This is an ongoing process, which requires constant perse-

Table 2 Some factors that influence attitudes toward sustainability

Knowledge	Information on the meaning of sustainability and its implications
Background	The nature of their training generally influences an individual's degree of receptivity to sustainability
Experience	Previous experience with environmental and social issues facilitates understanding of the role of sustainability
Perception	The integrated view of environmental, political and economic elements allows for a broader perception of sustainability
Values	Unlike previous factors because of their high degree of complexity, an individual's values usually determine whether his or her attitudes are favorable or not
Context	Sustainability is not only related to ecological factors per se, but also involves consideration of economic, political and social issues. However, links with the latter are often ignored by schools and universities

Source Adapted from Leal Filho (2000)

verance and dedication while maintaining a long-term perspective (Lozano et al. 2013a).

In this pursuit, Leal Filho (2000) presents some factors that influence attitudes towards sustainability and describes their implications. For the author, the understanding of such factors is important for allowing the integration of concepts and ideas of sustainability into the scope of university policies and curricula, as shown in Table 2.

Considering the particularities of each student, their university experiences and previous experiences, teaching sustainable development involves methodologies and systems of thought that require creativity, flexibility and critical reflection on society and its relations with the environment. Therefore, the greatest challenge today is to introduce sustainability into curricula, regardless of the course or level of training, in a way which effectively prepares future professionals to deal with the dilemma of sustainability and how it relates to the major challenges of this century.

3 Methodology

This study is characterized as a qualitative, descriptive and exploratory cross-sectional study. The study is exploratory because it intends to investigate the familiarity of the researcher with the phenomenon and the research environment. It sought to understand the perspective of the students of the Postgraduate Program in Administration at a university in the north of Rio Grande do Sul State in Brazil, on the factors that influence adoption of sustainability practices by an Institution of Higher Education. Moreover, the fact that the students did not have any formal discipline on the subject, reinforces the exploratory character.

The study was developed with a group of 18 master students of administration program from this HEI. We employed participant observation in a class on special topics in sustainability, and analyzed materials produced by the students during that course.

The dynamics of the class were based on the reading of three texts indicated by the teacher as pre-class reading (Nejati and Nejati 2013; Dyball et al. 2015). From the first moment of the class, the students were invited to reflect on the concepts of sustainability and their relationship with the practices developed by the HEI, answering individually, through post-its, four questions fixed on posters on the wall: (1) What is sustainability? (2) How can an HEI contribute to sustainability? (3) What are the motivations for an HEI to adopt sustainability strategies? (4) What are the obstacles an HEI faces in adopting sustainability strategies?

After briefly reflecting on the answers the class moved to a collective activity, in which the students thought about what sustainable practices could be carried out by the HEI. Students performed this activity in pairs with rotation, resulting in three rounds of debates. The discussions lasted 60 min and the mediator was the teacher. All the opinions of the students were recorded on posters. Subsequently the discussion of the posters, each student was asked individually to answer three questions: (1) In your opinion, what could be the values of an HEI with a focus on sustainability? (2) What actions could be taken by an HEI with a focus on sustainability? (3) Based on previous answers, which indicators could the university evaluate? The responses were analyzed using content analysis, as a form of triangulation of the data (added to the teachers' participant observation).

Finally, the students carried out an individual review of the class discussions, through a form that requested values, short-term, medium-term and long-term goals and performance indicators to be adopted by the HEI in the bias of sustainability practices. This information was transcribed in a spreadsheet for later analysis of the data.

4 Results

This research has the purpose of analyzing the perspectives of postgraduate students on sustainability education and practice at the University. During a topical post-graduate class, the Master's in Management students were invited to discuss their perspectives on sustainability at the university.

The dynamics of the discussion started from some questions about the concept of sustainability, where it was possible to perceive that the students' views on the matter are strongly linked to their perspectives on environmental preservation, the best use of available natural resources and related economic issues. However, sociocultural biases appeared to be the Achilles heel of sustainability according to the students, being mentioned a few times, indicated in Fig. 1.

When questioned about how HEIs can contribute to sustainability, students were emphatic in stating that the institution should act by example and teach sustainability

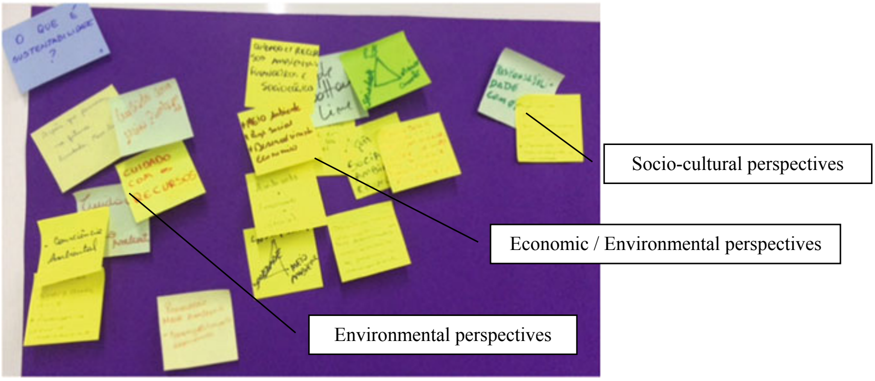

Fig. 1 What is sustainability? *Source* Results from the study, 2017

through concrete actions, involving both teachers and students, in teaching, research, and management. Another important point is the responsibility of the HEI in guaranteeing the effectiveness of the concepts based on discourse with government, the private sector, and by extension the broader community. The participants recognized the importance for students to take an active role in all sustainability practices at the university. This includes those practices in teaching, research, administration, extension activities and community outreach.

In following reflection, the participants questioned the motivations for adopting sustainability in the HEI strategy. In their opinion, the institution will adopt sustainable practices to the extent that it has some legal or financial incentive to do so. However, the social recognition, transformative power and visibility of the HEI's adoption of and action upon values related to sustainable development can be great motivators for society at large in the participants' view.

On the other hand, they emphasize the need for cultural change before the adoption of these strategies can take place. In the view of the students, resistance to change and lack of motivation, commitment and attachment of priority are the main obstacles to the adoption of sustainability strategies in the institution. The lack of knowledge on the subject, short-term vision, lack of resources to invest in this type of action and the need for greater internal and external discussion are cited as some of the barriers to be overcome by the HEI.

These reflections were followed by a second segment of the class, where the participants were invited to think about actions that could be carried out by the HEI to become a sustainable university. Here, three major proposals emerged: (a) the development of a formal organizational structure in the form of department or sector responsible for the internal and external articulation of the institution's sustainability practices; (b) development of continuing education for teachers and students in order to provide dialogue on the subject; (c) implementation of internal campaigns focused on the preservation of resources and of external campaigns to build awareness in society at large (Fig. 2).

Fig. 2 Group activities to suggest sustainable activities at HEI. *Source* Results from the study, 2017

Fig. 3 *Values Source* Results from the study, 2017

Finally, at the end of the class, the students were invited to make an individual review of the discussions, listing values and proposing short- and medium-term goals and indicators that can be adopted by the HEI in the pursuit of sustainable development. All terms were included in wordart.com to create the word cloud of Fig. 3.

When analyzing the values listed as important for the development of a culture of sustainability within the HEI, we notice that social responsibility, solidarity and ethics are highlighted. In the same way, through the discussion sessions we see that the concept of social perspective, which was not initially considered, gains notoriety accompanied by values such as creativity, innovation and entrepreneurship. This evinces the participants' emphasis on individual agency of university stakeholders in pursuing sustainable development and sustainability education.

Certain short and long-term practices proposed by the students to be adopted by the HEI stand out. These include the integration of practices in teaching, research and extension activities, and actions focused on resource management. These are illustrated in table three, which summarizes the recommendations of the students, grouped by type of action (Table 3).

Finally, the indicators of progress toward sustainable development goals proposed by the participants correlate to the goals of teaching, research, management and extension activities of the university, as can be seen in Table 4.

The amount of indicators proposed by the students show the potential the university has. Based on these indicators and on students' opinions recorded on posters, it's clear in the students view the need of (a) community engagement, which was pointed out by Ceulemans (2015a); and (b) sustainability evaluation criteria in areas as teaching, research and other functions, as stated by Souza (2016). Nevertheless, students' view don't reflect all points indicated by UNESCO (2005) and some operational topics.

5 Conclusion

In order to reorient education towards sustainable development, it is necessary to teach and learn the knowledge, skills, perspectives and values that guide and motivate people to seek sustainable ways of life and participate in a democratic society. In this sense, it is not enough that sustainability is only a theory. It must be experienced and understood by all stakeholders in the HEI, so that the culture of sustainability can be implemented into practice as a part of everyday life, both within and beyond the university walls.

Originally focused only on environmental issues, the sustainability concept progressed through discussion and debate towards the awareness of two additional sets of issues, such as socio-cultural and economic. This forms the recognized tripod of sustainable development concept (UNESCO 2005). With a focal group of 18 students of a Master Program from a Brazilian University, this paper discussed the understanding about a sustainable university, identifying their motivations and suggestions towards a sustainable HEI. The practices and suggested performance indicators demonstrate the students' understanding of the importance of involving all spheres of the University and the community in the debate on sustainability and makes clear the mission of the university to be a protagonist. The students gave examples of concrete actions in the university and in the community, the government, and the private sector. However, they also took a critical view on the distance between the academic sphere and the public and private spheres, making this approach the biggest challenge for the implementation of actions suggested by academics in the development of effective and holistic sustainability policies.

Table 3 Short and long-term practices proposed by the students

Teaching	Short-term practices	Students involvement with sustainable practices
		Link disciplines to the local reality
		Solidary student hazing
		Lectures that promote awareness
		Awareness and information campaigns
		Actions with the students to help the community
		Partnership with NGOs for trainees of students assisting people in social vulnerability
		Disseminate sustainability among groups in class
		Encourage with awards for innovations in sustainability
		Each graduating student to plant a tree that will bear his name
		Work sustainability as a compulsory subject
	Long-term practices	Make sustainability a transversal theme
		Theme inclusion in curriculum
		Create calendar with sustainable actions
		Bring the students to a semester contest of ideas focused on sustainability
Research	Short-term practices	Encourage students to research-action on the topic
	Long-term practices	Develop more applicable research on the subject and encourage teachers and students to apply it
		Projects implementation based on research results
		Encourage sustainability research
		Create a stamp to reward applied sustainable projects
		Offer to the market sustainability research projects, focusing on waste treatment, for example
		Community counseling and social guidance to help with development
		Establish contacts with institutions to promote sustainability actions
Outreach	Short-term practices	Partnership with government
		Urban projects
		Unite government and waste collectors
		Promote a local forum for sustainability debate
		Events focused on sustainability
		Initiate the discussion of ideas in primary and secondary schools (public and private)
		Structure the inclusion of the sustainability theme in HEI courses

(continued)

Table 3 (continued)

	Long-term practices	Create an open community council
		Create extension programs
		Involve the community in an awareness project with effective actions of sustainability
		Create councils (groups) to manage sustainability issues with society, student teachers and employees
		Law proposal to promote sustainable actions in the small companies of the region
		Demand from government more inspection
		Partnership with Public Prosecutor's Office to allocate fines to subsidize environmental projects
		Create calendar with sustainable actions
		Waste management with community
Management	Short-term practices	Create a sustainability code Place trash cans for selective collection
		Reduce energy and water consumption
		Use fewer disposable cups (students, teachers and staff)
		Use fewer paper for reporting and teaching activities
		Create trainings for all audiences
		Actions with suppliers to promote economic growth
		Creation of department to centralize actions
		Establish a sustainability committee
		Use of rainwater
		Use of environmentally friendly supplies
	Long-term practices	Architectural projects (ex: solar energy)
		Partnership with suppliers
		Partnership with model company in sustainability
		Base strategic planning on the sustainability tripod
		Create sustainability culture
		Correct destination of waste, turning them into resources
		Adequacy of campus structure based on sustainability (rainwater, solar energy)

Source Results from the study, 2017

Table 4 Performance indicators of university sustainability actions

	Indicators
Teaching	Awareness of students and teachers
	Evaluations of students on courses and concepts of sustainability
	Number of needy students who enter the HEI
	Number of actions proposed by students
	Number of works done by students
	Research with students to verify knowledge about sustainability
	Identify the reflection of the discipline sustainability in the career orientation of alumni
	Presence of discipline in the curriculum of the courses
Research	Researches on sustainability (other companies)
	Viable sustainability projects
	Number of final paper/thesis/dissertation regarding sustainability
	Positive image research
Outreach	Community assessments of HEI involvement
	Company's participation on the board
	Number of lectures for the community
	Number of effective partnerships
	Number of students/schools registered in actions with HEI, who participated in activities
Management	Economic viability
	Involvement with the sustainable issue
	Waste generated (tons)
	Programs created (participants and diversity)
	Trained people (quantity)
	Reducing consumption, saving resources (water, energy, glasses, paper)
	Financial indicators, which can provide indications of cost reduction
	Acceptance of implemented ideas/changes
	Re-adjustment of contracts with suppliers
	Social responsibility
	Organization's image (HEI)

Source Results from the study, 2017

Future research may benefit from a more judicious approach to students' perspectives through a quantitative study, which may confirm the perceptions of this study using the scale of Nejati and Nejati (2013). Research could also be applied to other higher education institutions to learn about other teaching experiences in other universities and other levels of academic training. Our research method can be used to a group of institutions, to benefit from a broader test base and compare it with our participants' opinions. This may bring new insights on the issue, including ways to implement sustainability and ways to raise the awareness of those involved, both in academia and in society at large.

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Interdisciplinary Cooperation and Collaboration in Undergraduate Sustainability-Based Programs: A Canadian Example of Environment and Urban Sustainability (EUS)

Michal Bardecki and Andrew Millward

Abstract While much of the literature on urban sustainability tends to focus on the importance of protecting natural systems and determining engineering and technical solutions, many of the central challenges to envisioning and delivering appropriate and meaningful sustainability lie within social, cultural, and political structures. This paper draws on the insights related to the development and implementation of the undergraduate program in Environmental and Urban Sustainability (EUS) at Ryerson University (Toronto). The conceptual framework of the program reflects the need for a broad foundation of sustainability education which spans disciplinary boundaries. EUS has blended new and existing teaching configurations, and has embraced both cross-disciplinary and disciplinary content and academic structures in its curriculum development and course offerings. The key to success has been the merging of existing course offerings from fourteen disciplinary areas as part of the core of the EUS program structure. Since the program operates concurrent with existing academic departments and schools (each of which has at least one of its own programs), developing cooperation and collaboration, while vital to program success, has been an enduring challenge. Within this context, the paper discusses the motivations and processes of ongoing program and curriculum development.

Keywords Education · Undergraduate program · Urban sustainability · Curriculum · Interdisciplinary

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1 Introduction and Context

In Canada, education lies within Provincial jurisdiction; Federal involvement is limited. Each of the ten provinces and three territories has its own system for providing post-secondary education. These systems are overwhelmingly in the public sector as there is a very small private sector involvement in Canadian postsecondary education.

The province of Ontario has a binary system of post-secondary education, with separate systems of universities and colleges. The colleges system (Colleges of Applied Arts and Technology and Institutes of Technology and Advanced Learning) generally provide more technically-focused education and since 2012 have offered bachelor's degree programs. There are limited connections between the colleges and universities, although there are new linkages and developing interrelationships between individual colleges and universities in providing joint programs and credentialing.

There are 21 universities in Ontario ranging in size from University of Toronto with over 80,000 students on three campuses to Algoma University with an enrolment of about 1000. Individual universities have a wide-latitude in self-regulation through the Council of Ontario Universities, although the Province retains overall oversight and financial control.

Ryerson University is a comprehensive university imbedded in the heart of Toronto, Canada's largest city (2.7 million inhabitants). In the 2016–2017 academic year there were 35,166 full- and part-time undergraduate students in 62 programs (31,574 full-time equivalents [FTE]), 2605 students in 49 Master's and 15 Ph.D. programs (2107 FTE), and 66,461 course registrations in Continuing Education. The university has 877 full-time faculty members (plus sessional and part-time instructors). The University is academically divided into six Faculties, each headed by a Dean:

- Faculty of Arts
- Faculty of Communication & Design
- Faculty of Community Services
- Faculty of Engineering and Architectural Science
- Faculty of Science
- Ted Rogers School of Management.

Moreover, both Graduate Studies and Continuing Education, the Yeates and G. Raymond Chang Schools, respectively, operate at a decanal level in the university structure.

Ryerson University has undergone a transformative change since the start of the millennium as a result, in part, to a change in the university's mandate. This led to a period of unprecedented growth as student numbers and the faculty complement expanded. Between the 2001–2002 and 2016–2017 academic years the university's undergraduate FTE expanded 2.4 times from 21,987 to 31,575. The first graduate programs were introduced in 2000–2001. Full-time faculty numbers grew from 537 to 877. In the Faculty of Arts, proportional change was even more dramatic as FTE undergraduate enrolment expanded from 2001–2002 to 2016–2017 by 8.6 times from 444 to 3833, and full-time faculty numbers increased from 100 to 214.

2 EUS: The Drivers

It was within the broader context of university-wide transformation that a proposal for a new undergraduate program in Environment and Urban Sustainability (EUS) was developed. Although the idea arose in a conversation between one author (MB) and the then-Dean of Arts, the development of the EUS program proposal was very much bottom-up in that it received no administrative sanction nor funding support. However, the initiative did spring from a series of contextual "drivers":

- A University-wide sustainability initiative focused on facilities management and in education programming;
- The growth in student numbers;
- The decision for pedagogical and logistic reasons to constrain the growth of student numbers in existing Arts programs and prioritize the development of new programs;
- The success of the existing interdisciplinary MASc/Ph.D. programs in Environmental Applied Science and Management; and,
- An Ontario-wide languishing of enrolment in university Geography programs.

Ryerson University "committed to actively pursuing a more sustainable future for our campus and the world beyond its borders. Sustainability… means taking responsibility for a shared future with the broader community, and aiming to pursue environmental, social and economic sustainability through our programs, Scholarly Research and Creative (SRC) activity, policies, built environment and fiscally sound operations" (Ryerson University 2017). This commitment is now manifest in developments such as the more than 340 undergraduate courses focused on or related to environmental and/or social sustainability (notably in Architectural Science, Food Security, Global Management Studies, Mechanical Engineering, and Urban and Regional Planning), new research centers including the Centre for Urban Energy and Ryerson Urban Water, benchmarking and operational changes to address greenhouse gas emissions, waste reduction initiatives, the development of a rooftop urban farm and farmer's market, and the development of an internal sustainable certification program. The proposal for the development of the EUS program, as the first environment- and sustainability-focused undergraduate program, melded well with the university's overall commitment.

As noted above, undergraduate enrolments at the university and within the Faculty of Arts were expanding. Existing Faculty of Arts' programs were seen as differentiated from those at other universities in part by relatively low student numbers, especially in the first year. Concerns over the loss of this appeal and the university-wide dearth of large lecture halls resulted in the choice to add new programs rather than allow unlimited increases in enrolments within the existing ones. A new program proposal building on existing faculty interests supported the plan.

Ryerson's MASc program in Environmental Applied Science and Management (EnSciMan) started as an interdisciplinary initiative with faculty members from eight schools and departments: three engineering departments, chemistry and biology, geography, public health, urban and regional planning, and economics (Bardecki and Pushchak 2014). The first students, in 2000, were members of the first cohort of graduate students at Ryerson University. As of January 2018, EnSciMan had 94 member professors—amounting to 11% of the university's faculty complement (including representation from 27 different schools and departments in each of the university's Faculties). EnSciMan's level of successful collaboration in bringing together a large and disparate group of academics in a common cause of teaching, supervision and research has been perceived within the university as a model of interdisciplinarity (Bardecki 2015), and a basis for cooperation in a new undergraduate sustainability-focused program.

The Department of Geography has operated an undergraduate program within the Faculty of Arts since the 1970s (originally a Bachelor of Applied Arts in Applied Geography, now a BA in Geographical Analysis), and a master's level degree in Spatial Analysis since 1990. However, over this period, Geography as a discipline has seen challenging circumstances. With curricular change and a move to more instrumentalist education, the emphasis on the subject in secondary schools has decreased with markedly lower enrolment in university Geography course offerings (Mansfield 2005). As a result, across the Ontario university system application numbers to Geography programs are down and, with a lack of exposure to the discipline, course enrolments are often challenging. The majority of the province's universities do offer undergraduate Geography programs (17 of 21), but students are now drawn from a smaller pool. Strategies for attracting a new group of applicants had been a point of discussion within Ryerson's department for at least twenty years. Department involvement with the creation and hosting of the new EUS program was seen as such an opportunity.

3 EUS: Program Objectives

The need to reorient education towards sustainable development and that such initiatives need to be interdisciplinary in their approach was recognized in the Talloires Declaration's (Principle 7) call for the development of interdisciplinary curricula to support an environmentally sustainable future (Wright 2002). The graduate EnSciMan program had already gone a long way to breaking down the traditional disciplinary silos which have been identified as barriers to the implementation of sustainability-based programs elsewhere (Ralph and Stubbs 2014; Welch-Devine et al. 2014). This provided some assurance from the start that the EUS program development could draw on constructive relationships with academic units and individual faculty and program administrators which were already in place to create an interdisciplinary framework for the new program.

The ties of the new EUS program with the Department of Geography were in keeping with the discipline. Sustainability has been seen as more readily absorbed as a pivotal concept into certain disciplines such as Geography and Biology (Reid and Petocz 2006; Cotton et al. 2007) and geographers generally identify themselves as members of a bridging discipline (Baerwald 2010; Youngblood 2007); moreover, geographers have been among the leaders in addressing new initiatives of sustainability and sustainable development at universities (Kagawa 2007). Environmental studies have often been paired with Geography (Leduc 2009/2010). Harvey et al. 2002) and, as elsewhere, a number of the Geography programs in the province have rebranded themselves to include some reference to "environment" in the departmental name. Working with an existing disciplinary-based department also negates many of the issues associated with the options of "loose collegiums and rigid quasi-departments", "risking either isolation or internal competition. Neither of them is easily able to directly engage with undergraduates: loose structures do not because staff who are members do so via their departmental homes; rigid structures do not because they have none, and are also typically funded for research only" (Sherren 2008).

The EUS curriculum sought to balance providing a core of required courses with offering a high degree of access to electives from multiple fields. Except among those training scientific and engineering specialists in the field, flexibility is seen as a key element in the design of curricula for sustainability education (Vincent and Focht 2009). The EUS curriculum sought to incorporate a "broad" (in the sense of Newell 2007) form of interdisciplinary thinking; that is, involving integration across the boundaries among traditional groups of disciplines, such as between natural and social sciences or humanities.

Use of independent study, internships, and experiential learning has been seen as critical in interdisciplinary programs, including those that involve sustainability education (Cortese 2003; Holley 2009; Benton-Short and Merrigan 2016). Incorporating these opportunities was seen as essential for student engagement and the overall success of the EUS program.

As in many countries (McLendon et al. 2009; Altbach et al. 2010) over the period of the last few decades higher education in Canada has experienced a decrease in government funding both in aggregate and on a per student basis (Fisher et al. 2009; Metcalfe 2010). With the all universities being publically-funded, this meant a general fiscal belt tightening and climate of cost rationalization permeated the university system. Existing departments compete for physical and budgetary resources. As with any new course, approval of the EUS program proposal required a high degree of sensitivity to costs and it was seen as important to be able for the program to operate in such a way as to require as little as possible in the way of additional faculty instructors or physical and budgetary resources.

4 EUS: Constraints to Program Structure

Two particular constraints bound the development of the configuration of the EUS program's curriculum. One of these existed at the level of the Faculty of Arts: the Arts "platform." The other was the University-wide requirement for a tri-partite curriculum structure.

Although students in Ryerson's Faculty of Arts are directly admitted into one of (now) thirteen disciplinary-based programs (only a small proportion of students are "undeclared"), the curriculum for each program within the Faculty builds on a common foundational year of interdisciplinary study in the Humanities and Social Sciences. In their first year, each student is required to take core courses[1] in writing, critical thinking, and an introduction to social Science, as well as select from a broad array of electives. Effectively, this common platform structure would allow EUS students to select only two courses from their area of study in their first year, but does compel selection from a wide array of subjects. The platform also requires two courses in year two in research and qualitative methods, and statistics. This curriculum structure still allows for a specialization made up of 20–21 courses.

Ryerson's Tripartite Curriculum statement declares that "All programs at Ryerson University have a tripartite curriculum structure. This structure was developed in order to ensure that all Ryerson University students are exposed to a body of material from within their own discipline, a body of material relevant to their own discipline but delivered by other disciplines, and breadth in the form of material deliberately not from their own discipline." In practice, this means that each the curriculum in each program is divided into three categories of courses:

- Professional Studies: core courses in the career field, which are to constitute 50–75% of the curriculum;
- Professionally-related Studies: courses that develop an understanding of the theoretical disciplines of the career field, or which develop elements of professional study, which are to constitute 10–40% of the curriculum; and,
- Liberal Studies: courses that develop the capacity to understand society and culture (elsewhere these might be called "general education") which are to constitute 8–20% of the curriculum.

5 EUS Program Development

The new program underwent the mandated approval process, as follows:

[1]At Ryerson University an individual "course" fits into a 12-week semester which would typically involve 36+h of in-class time. To graduate a student would take 40 or, depending on the program, more courses—typically at least five per semester in full-time study in each of two semesters per year.

1. Preliminary Proposal Letter of Intent (LOI); authorized by Provost to proceed to the development stage of a formal proposal;
2. Development of new program proposal; submitted to the Vice Provost Academic and Vice Provost University Planning;
3. Review/approval of new program proposal; by Department Council and Dean of Arts, Academic Standards Committee review;
4. External peer review and site visit;
5. Submission to the Vice Provost Academic;
6. Review of the new program proposal by Academic Standards Committee;
7. Senate approval;
8. Provincial Quality Council approval; and,
9. Report to the Board of Governors.

As part of the process, the proposal went through the process of provincially-mandated curriculum mapping (Lennon 2014; Lennon and Frank 2014). After approval, the first cohort of the EUS program entered in September 2012 and the Department of Geography was renamed the Department of Geography and Environmental Studies.

The structural underpinnings of the program are based on the idea of a T-shaped curriculum. The issue in many undergraduate interdisciplinary programs is that they are focused on general education and/or allow for a high degree of individualization; the rigour of these 'quasi-self-directed' approaches has been questioned (Newell 1992; Soule and Press 1998; Holley 2009). The idea of T-shaped expertise arose in the 1990s in the field of computer technology (Heinemann 2009). Figuratively, the horizontal crossbar represents an ability apply a set of skills that allow one to communicate, understand and apply knowledge across fields outside one's principal area of expertise and to collaborate with those in those in different areas of expertise (Fig. 1). The vertical dimension represents a depth of understanding and skill in a specific field (such as communities and sustainability, or sustainable design). The goal of shaping a T-shaped professional has been seen as important in the development and delivery of a wide variety of discipline areas at universities (e.g., Bitner and Brown 2008; McIntosh and Taylor 2013; Bardecki 2015). Rather than focusing on solely developing a breadth of knowledge, a T-shaped curriculum would provide problem-solving and research depth in one or more areas of expertise while incorporating that overall breadth in the understanding of a range of other fields. A need for "meta-experts" to broker among different disciplinary experts and between experts and non-experts has been noted as important in the development of sustainability (Brand and Karvonen 2007). In addition, students possessing skills as both "specialists" and "generalists" may be better able to adapt to the inevitable fluctuations in the job market (Krozer 2005).

Vincent and Focht (2011) identify broadly-defined curriculum models in use in university environment programs: one based in the natural sciences and focused on the development of technical knowledge and research, and a second, centred in the social sciences, focused on policy, governance and advocacy. The EUS program exhibits more of the character of their third model: as one with an interdisciplinary-

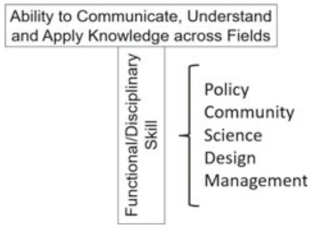

Fig. 1 T-Shaped skills development in EUS

Table 1 Academic units offering required and elective professional studies course offerings in EUS

Faculty of Arts • Department of Economics • Department of Geography and Environmental Studies • Department of History • Department of Philosophy • Department of Politics and Public Administration • Department of Psychology • Department of Sociology
Faculty of Communication and Design • School of Interior Design
Faculty of Community Services • School of Occupational and Public Health • School of Urban and Regional Planning
Faculty of Engineering and Architecture • Department of Architectural Science
Faculty of Science • Department of Chemistry and Biology • Ted Rogers School of Management • Department of Law and Business • School of Hospitality and Tourism Management

based management focus emphasizing problem analysis and solutions. The conceptual framework of the program reflects the need for a broad foundation of sustainability education which spans disciplinary boundaries. EUS blended new and existing teaching configurations, and has embraced both cross-disciplinary and disciplinary content and academic structures in its curriculum development and course offerings (Table 1). The key to attainment was the merging of existing course offerings from fourteen disciplinary areas as part of the core of the EUS program structure. Outside the Faculty of Arts, the "right" of access by students to individual courses required negotiation and formal confirmation by each department or school as part of the program approval process.

The requirements of the Faculty of Arts platform and the tri-partite curriculum structure ensured a degree of interdisciplinary breadth. This was carried through to the core of the broad base of courses available as electives in both professional studies

Table 2 Basic EUS program structure

16 Enquired courses • 4 in Arts Platform • 12 in Professional Studies
24–26 elective courses • 4–6 in Arts Platform (of 28) • 8 in Professional Studies (of 43) • 4–6 in Professionally-related Studies (of 205) • 6 Liberal Studies courses (of 348) • 2 Internship Placements (optional)

and professionally-related studies (Table 2). At least one EUS Professional Studies course is required in each semester.

Five thematic areas of study were identified as interdisciplinary streams within the curriculum:

- Environmental Policy;
- Communities and Sustainability;
- Environmental Science;
- Sustainable Design; and,
- Environmental Management.

These were seen as representing the "depth" of the program. Students, with the aid of academic advising, can identify coherent areas of specific interest and distinguish potential career paths. Specific course choices reinforce these areas (Table 3).

Table 4 uses a set of disciplinary categories derived from O'Byrne et al. (2015) to classify the required courses in the program (Arts platform and Professional Studies) and electives courses in Professional Studies to illustrate the interdisciplinary breadth in EUS. O'Byrne et al. (2015) found that none of the programs they investigated covered all categories and that the average program had courses in six of the 10.

General sustainability courses provide the year 1 introduction to the program. Applied sustainability is addressed in a series of required and elective courses in years 2 through 4. Beyond the required courses, the wide range of elective courses ensure that options for Professional Studies courses are available in each of the disciplinary categories of the Natural, Social and Applied Sciences, and Organizations (Business), as well (to a lesser degree) in the Arts and Humanities.

Prerequisites for all courses are built into the curriculum; that is, they are required courses or part of the Professional Studies electives, or can be taken for credit as Professionally-related Courses. This can be a barrier to entry in the Natural Science courses, as some of the Professional Studies courses there are offered at an upper level with one or more prerequisites.

The components of experiential learning, the "applied work" which O'Byrne et al. (2015) identify as involving problem solving with "active engagement with actors, organizations, or communities outside of the classroom" is embodied in several courses, but particularly in the fourth-year required course, EUS 801 Senior Projects

Table 3 Examples of professional studies electives by field of study

Environmental Policy	ECN 502 Economics of Energy and Natural Resources ENH 825 Risk Assessment EUS 450 Responses to Climate Change GEO 671 Developmental and Environmental Law PHL 525 Environmental Ethics PLE 715 Environmental Assessment POG 415 Environmental Politics and Policy
Communities and Sustainability	ASC 403 Site Development and Planning EUS 550 Sustainable Cities: A Review EUS 750 Sustainable Trans and Energy Strategies EUS 760 Cities at Risk EUS 850 Sustainability in Organizations GEO 851 GIS, Geographic Data and Mapping SOC 708 Environmental Sociology
Environmental Science	BCH 261 Biochemistry BLG 340 Environmental Biology BLG 401 Ecotoxicology CHY 423 Environmental Science ENH 122 Introduction to Epidemiology EUS 870 Ecological Restoration OHS 322 Introductory Toxicology
Sustainable Design	ASC 102 The Built World ASC 200 Sustainable Practices ASC 403 Site Development and Planning ASC 852 Landscape Ecological Design ASC 855 Sustainable Ratings Systems IDE 309 Sustainable Design PSY 518 Environmental Psychology
Environmental Management	ENH 324 Wastewater Treatment Systems ENH 524 Pollution Control EUS 650 Waste and Waste Management GEO 411 Resource and Environmental Planning GEO 513 Physical Geography in Decision Support GEO 514 Resource Management in Northern Canada GEO 612 Environmental Decision Making

in Environment and Urban Sustainability, which is built on a consulting model in which each team of students acts as a research consultancy preparing a report for an outside "client" agency or organization—this builds on the over 30-years of experience that the geography department at Ryerson has had with a similar course in its complementary Geographic Analysis program (which focusses on geographic information systems and other technologies) and has been seen as a particularly useful component of sustainability curricula (Barron et al. 1998; Bacon et al. 2011). In addition, there is an international Field Studies course (EUS 880), and two optional internship placement credits (EUS 900 and EUS 901) which are available for students who avail themselves of summer placement positions.

Table 4 Disciplinary categories for EUS professional studies courses (required and elective) (categories based on O'Byrne et al. 2015)

Disciplinary category	Required courses	Professional Electives
General Sustainability	EUS 102 Environment and Sustainability EUS 202 Sustaining the City's Environments	
Applied Sustainability	EUS 301 Reading Neighbourhood Environments EUS 401 Patterns of Demography and Environment EUS 501 Ecological Processes in the Canadian Landscape EUS 601 Nature in Fragments: The Legacy of Sprawl	EUS 450 Responses to Climate Change EUS 550 Sustainable Cities: A Review EUS 650 Waste and Waste Management EUS 750 Sustainable Transportation and Energy Strategies EUS 760 Cities at Risk EUS 860 Measuring Sustainability EUS 870 Ecological Restoration
Methods	SSH 301 Research Design and Qualitative Methods EUS 402 Research and Statistics EUS 701 Field Studies in Urban Ecology	ENH 122 Introduction to Epidemiology GEO 581 GIS, Geographic Data and Mapping GEO 681 GIS and Geographic Analysis
Research		
Applied Work	EUS 801 Senior Projects in Environment and Urban Sustainability	EUS 880 Field Studies EUS 900 Internship Placement I EUS 901 Internship Placement II
Natural Sciences	BLG 143 Biology I ENH 617 Applied Ecology GEO 313 Geography of the Physical Environment GEO 513 Physical Geography in Decision Support	BCH 261 Biochemistry BLG 340 Environmental Biology BLG 401 Ecotoxicology CHY 142 Organic Chemistry I CHY 423 Environmental Science OHS 322 Introductory Toxicology OHS 422 Advanced Toxicology

(continued)

Table 4 (continued)

Disciplinary category	Required courses	Professional Electives
Social Sciences	POG 377 Urban Sustainability Policy	ECN 502 Economics of Energy and Natural Resources ECN 510 Environmental Economics GEO 411 Resource and Environmental Planning GEO 514 Resource Management in Northern Canada GEO 612 Environmental Decision Making POG 415 Environmental Politics and Policy PSY 518 Environmental Psychology SOC 708 Environmental Sociology
Applied Science (Engineering)		ASC 102 The Built World ASC 200 Sustainable Practices ASC 403 Site Development and Planning ASC 852 Landscape Ecological Design ASC 855 Sustainable Ratings Systems ENH 324 Wastewater Treatment Systems ENH 524 Pollution Control IDE 309 Sustainable Design
Organizations (Business)		EUS 850 Sustainability in Organizations GEO 671 Developmental and Environmental Law HTT 510 Sustainable Tourism LAW 535 Environmental Law and Business PLE 715 Environmental Assessment
Arts and Humanities	SSH 105 Critical Thinking SSH 205 Academic Writing and Research	HIS 828 Science, Corporations and the Environment PHL 525 Environmental Ethics

No explicit "Research" course, i.e., "systematic work with the aim of producing new knowledge" involving a thesis or research paper (O'Byrne et al. 2015) is included in the curriculum. As O'Byrne et al. found, this form of course offering is more characteristic of graduate-level programs.

6 EUS Minor

At Ryerson University, a Minor is an opportunity for a student to study a second academic theme as a matter of personal interest, or to develop an area of specific expertise related to the student's area of study. The curriculum of each goes through a review process and is approved by the University Senate. Currently, there are 55 Minors, in a wide variety of subject areas, at Ryerson, each consisting of six courses from a coherent set of required and elective courses. Students do not declare the Minor until the time that they apply to graduate and the achievement is noted on the student's academic transcript.

A Minor can be delivered by a program's home department using current courses, and with existing resources, while at the same time embedding the opportunity for sustainability-based learning across the university. The EUS Minor received Senate approval in November 2013. The only students ineligible for the Minor are those in the EUS program itself. Because of duplication between the Minor's requirements and courses available as part of their degree requirements students in eight programs (Architectural Science, Biology, Geographical Analysis, International Economics, Occupational Health and Safety, Politics and Governance, Public Health and Safety, Urban and Regional Planning) may require only four courses to receive the Minor.

7 The Realities

EUS application numbers were strong from the start of the program. In its first year, 850 students applied for 82 positions. Application numbers have eased somewhat but remain robust. Historically, environmental studies programs have tended to attract engaged and action-oriented students and similarly oriented faculty (Altbach 1997; Klee 1983). That has been the case with those in the EUS program. For example, twelve Ryerson students travelled from Toronto to New York City in 2014 for the People's Climate March (Jensen 2014). In 2016, motivated by his environmental and social convictions, eight students and faculty again traveled to New York City to rally on behalf of the candidate for US Democratic Party leadership, Senator Bernie Sanders.

EUS students have also been active in embracing the opportunities in Zone-based Learning at the university. Zone learning is a new model of experiential learning embraced by the university which, through mentorship, workshops, and entrepreneurial and analytics training, provides opportunities for students to develop their own projects, causes, or startup companies (Castillo and Meyer 2018; Zone Learning n.d.). Moreover, while we do not as yet have robust data on employment success, a number of graduates from the first and second EUS cohort have moved on to graduate programs at both the Masters and Ph.D. level, where they are studying at universities across Canada.

Notwithstanding many notable achievements of the EUS program and its students, there has been some regression from the initial program proposal to incorporate interdisciplinary measures in the practical operation and delivery of the program. Rather than developing, as was initially envisioned, an interdisciplinary council incorporating representation from other schools and departments across the university, oversight for the EUS program was fully absorbed into the Departmental Council of Geography & Environmental Studies. Similarly, all new faculty hiring has been of individuals with a background in Geography (although one Engineer has been hired in a sessional capacity to teach a waste management course).

In addition, the collaborative strength underpinning the program at its inception has been hard to maintain as personnel, particularly as those of school and department chairs who were party to the original agreements, move from their positions and where new administrators often need individually to be convinced of the merits of their academic involvement in EUS. Disciplinary self-interest has meant that difficulty has arisen in assuring that EUS students have equal and free access to courses outside the control of their home department. Understandably, given the choice, if numbers are restricted, EUS students may be sidelined. This is particularly true in professional programs where academic "turf" may be seen as needing protection, and in courses that have mandatory laboratory components where seating and access to equipment is limited. On the other hand, there is a certain degree of centripetal character to students' course selection: that is, given students are predisposed, and perhaps encouraged, to limit the scope of their course choice, they have disproportionately opted for those courses with the EUS code. This is also reflected in the relatively low enrolment numbers in the EUS Minor.

Finally, the effort during the process of designing the EUS curriculum to ensure that the program could be offered with a need for relatively little in the way of new resources has led to a chronic level of underfunding, particularly in that the original financial analysis was based on conservative enrolment numbers (some 30% lower than current). Nonetheless, six new faculty have been hired to teach in program—revitalizing the Department and dramatically increasing research funding and productivity.

8 Conclusion

There has been a focus in the literature on the analysis of appropriate pedagogical approaches to teaching sustainable development. The first lesson that we draw from our involvement with the development of the EUS program is that interdisciplinarity is possible within a department/school structure. However, our experience, and the experience of others (Matthew and Rolls 2016; Leal Filho et al. 2017) show that it can be problematic in practice.

Even in the absence of direct support from the university administration in the EUS program proposal, the situation we have faced had considerable initial advantages:

- There was a manifest opportunity for change within a dynamic university environment;
- The university was moving forward with a commitment to sustainability, which included incorporating these goals through its programs;
- An atmosphere of collaboration existed among individual faculty and academic units—largely as a result of the experience collaborating in the graduate EnSciMan program;
- The Department of Geography and Environmental Studies was seeking a means to revitalize admissions;
- The adoption of the T-shaped curriculum model to guide program development; and,
- Rather than a need to focus on the identification of specific core competencies in sustainable development and teaching to those, we were able to draw on a large pool of existing courses and university-wide expertise to expand the framework of understanding.

As Pearson et al. (2005) suggest, and we have found, "working across boundaries will make things appear less tidy." As personnel changes and institutional memory lapses, as resources are more and more constricted, and as students tend to opt for the more comfortable disciplinary home, the interdisciplinary nature of the program continues to morph and adapt. Thus far, these challenges have not undone EUS and, on balance, the program's vitality remains strong. Nevertheless, as we have attempted to do in this paper, critical review is necessary to maintain a healthy vigilance where stewarding of similar interdisciplinary and cooperative programs is concerned—programs like EUS are unlikely to run themselves if left unattended.

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Adventure Cards, Process Wheels, and a Vision for Digital Storytelling: Learning from Leonardo

Paul J. Wolff, III

Abstract This work examines the phenomenon of the Living Lab Transaction and several user-engagement innovation tools developed to maximize meaningful interactions at the Massachusetts Institute of Technology (MIT), a private research university located in the northeastern region of the United States. Although much of the research at MIT is focused outwardly on solving universal challenges such as poverty, world hunger, and global economic issues, many students, scholars, and staff intentionally use the 168-acre campus—located within the city of Cambridge, Massachusetts—as a working laboratory in which to experiment with ideas, inventions, technologies, and new ways of thinking [In recent years, MIT has demonstrated a significant commitment to using the campus as a test bed (i.e., "living labs"), as evidenced in the launch of an Office of Sustainability that advances the educational mission of the institute (2013), in the *Plan for Action on Climate Change* (2015), in the creation of a new full-time appointment (i.e., the "Living Lab Design Manager") with responsibilities for cultivating research that uses the campus as a test bed for innovation (2016), and in the *Pathways to Sustainable Leadership* document (Campus Sustainability Task Force, 2017)]. New tools such as the *Process Wheels*, the *Learning Adventure Card* user interface/database, and the *Discover Living Lab Web App*, which are based on the conceptual Urban Living Lab Learning Frameworks (UL3), are introduced as examples of customizable, shared resources that cultivate leadership, team building, and creative problem-solving skills. The tools address common challenges that can thwart agility for project teams; they are designed to facilitate deeper learning and new ways of seeing by weaving together knowledge from fields such as cognitive science, fine arts, developmental psychology, philosophy, organizational behavior, applied mathematics (game theory), and from popular culture.

Keywords Living lab · Innovation and communication tools · Knowledge database · Leadership and team building · Campus as a test bed · Boundary objects · Living lab frameworks · Digital learning

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1 Introduction

Cultivating the transactions that occur between diverse stakeholders involved in living lab research can maximize novel innovations and potential impacts. Yet the intensity and depth with which higher education institutions consider these interactions and the tools developed to facilitate the co-production of knowledge differ significantly.

This work examines the journey of grappling with the common challenges of facilitating campus-based research (i.e., "living labs") within the uncontrollable dynamics of real-world environments at MIT. I have conducted a two-year immersion study of living labs and recorded observations obtained from the unique vantage point as one of the first-known individuals to hold a full-time appointment dedicated to cultivating living-lab-related research within the context of the US higher education system. Front-line observations were recorded (in a series of lists, drawings, sketches, survey results, and interview transcriptions), analyzed, and combined with equal parts imagination and fantasy to create new engagement tools that intentionally wander across the disciplines of the arts, sciences, engineering, and humanities, as well as integrate elements of popular culture.

I share perspectives based on real-world experiences gleaned from the struggle to answer common questions such as, What is a living lab? How does it work? and How can this innovation platform be cultivated to maximize impacts? In response to the observed problems and barriers that can thwart agility, a suite of tools have been developed to meet universal challenges related to project management, communication, data collection, team building, and the desire to maximize outcomes.

2 Context

Although scores of faculty, students, and staff have been conducting place-based research during the past 30 years throughout the world, evidence suggests that living labs have, until recently, been a predominantly European phenomenon. Besides geographical diversity, there is also a recent increase in the scope of sectors involved, the topics covered, and approaches taken in practice and research (Schuurman et al. 2017).

There is a considerable amount of research on living labs regarding definitions (Dutilleul et al. 2010), methods (Callaghan and Herselman 2015; Ståhlbröst 2008), the concept of agile design (Almirall et al. 2012), the use of living labs as a collaborative or transdisciplinary environment (Farley et al. 2010; Van der Walt et al. 2009; Weinstein 2010), and with regard to history (Bajgier et al. 1991; Moffat 1990; Tarricone 1990). There are also guidebooks (Schumacher 2010) and manuals (Ståhlbröst 2013) that share best practices, precedents, and strategies. Review of this literature confirms that there are numerous interpretations of the "living lab" and its defining characteristics (Leminen et al. 2015).

Earlier research developed frameworks to assess the performance of living labs and explored evaluative tools such as the Harmonization Cube, which attempted to align methods and tools used in the European Network of Living Labs and assess interoperability for organizational, technical, and contextual issues (Mulder et al. 2007). Others, such as Ayvari and Jyrama (2017), have conducted research on management tools for living labs, discussed the use of tools for different phases of living labs (Ståhlbröst and Holst 2013), and have noted a need to investigate tools in living labs, as this topic is under-researched (Bergvall-Kareborn and Ståhlbröst 2009; Ståhlbröst 2008).

This study seeks to contribute to this body of scholarship by examining innovation tools designed to develop team-building skills (the *Process Wheels*), document the stories of living lab research (*Learning Adventure Cards*), and share a vision for building a digital storytelling machine (*Living Lab Web App*).

3 Methods and Questions

I conducted a comprehensive listening tour of academic and operational units, speaking with directors, administrators, faculty, senior leaders, external partners, staff, and students affiliated with MIT to gain an understanding of ideas, aspirations, successes, and obstacles and to examine the landscape surrounding campus-based research.

This tour was divided into three phases; targeting academic units first and then operational departments and student groups. I compiled findings from 33 in-person interviews and collected structured and unstructured data from 62 identified projects that utilized the campus as a test bed for sustainability-related research during the past 12 years. In summary, three key findings emerged: confusion about the term "living lab" (mentioned by 59%), interest in learning how better to communicate research findings (mentioned by 52%), and the need to connect with the right people and processes (mentioned by 38%). With these themes as guideposts, I worked extensively with internal stakeholders—including faculty, staff, students, administrators, and external partners—during the following months in an effort to develop working definitions for the term "living lab," to gain an understanding of how they work, and to encourage an emergent community of practice.

The process of maintaining and cultivating new work generated new questions. For example, How can the complex process of living lab research, which often involves multiple stakeholders and divergent timelines and objectives, be managed? How can progress be measured through time? When pondering the answers, it was soon discovered that the typical living lab contained many moving parts and opposing timelines. For instance, researchers followed a sequence driven by academic interests and/or funding sources, while operational experts followed production deadlines, fiscal budgets, and/or specific directions from senior leadership. The creation of a new character in this drama (i.e., the Living Lab Design Manager) added new intentions to bridge between operational and academic units, to nurture informal and formal learning activities, to cultivate funding opportunities, and to document living lab research as it happens. It was a response to the complexity of the living lab ecosystem—and the need for organizational tools that connect people, ideas, and processes—that led to the creation of tools which seek to organize the concurrent processes and timelines and to document progress through time (see the section "Transaction Tools").

A second question that emerged was, How can the stories of living lab research be documented and shared more easily? Although new research was often documented carefully on websites, or in recently published articles, the retrieval of older work was more challenging. As a result, details of the front-line stories of research and the place in which it occurred may only be available in the minds of those who did the work, or who remember it as a bystander. In response to these challenges, a concept was conceived as a means to collect and share the stories of living lab research (see the section "The Learning Adventure Card Concept").

A third question in response to the observed collection and retrieval challenges was, how can the findings of campus-based research be scaled to be accessible for wider audiences (including novices, experts, and a growing cadre of "digital natives[1]")? The solution that emerged was an idea for a dynamic digital tool that allows large amounts of structured and unstructured data to be collected, stored, and retrieved via an interactive, app-like interface (see the section "A Vision for a Digital Storytelling Machine").

4 Transaction Tools

Scholars have described the messy, unpredictable nature of campus-based research as "in-the-wild" experimentation and have examined the influence of context on the user experience (Ballon and Schuurman 2015). A similar variety of processes were observed in the 62 living labs that were examined for this study, but three were the most prevalent: a *research process* (research questions, literature review, design methodology, and data collection/analysis), an *ideation process* (intake/define, collaborate, digest, prototype, connect/reconnect, and test/outcomes), and a *filtering process* utilized as a means to make strategic decisions about the prioritization of new work (scales of impact, alignment with institutional goals, capacity for formal or informal learning, risk assessment, etc.). So, in an effort to collect these simultaneous processes in one device and as an aid to the application of new knowledge, I imagined the *Process Wheels,* which are meant to support deep learning and high-level skill development such as analysis, synthesis, and creative problem solving required for active participants in living lab research (see Fig. 1).

The *Process Wheels* were inspired by the analogy of an artist's color wheel—a device that collects large amounts of complex information related to color physics and

[1] "Digital natives" are those born after 1980, who have grown up with video games, instant messaging, and smartphones and who prefer to learn from hyperlinked, random access, digital sources and with the assistance of online cameras, simulations, games, wikis, and blogs that they help create (Kelly et al. 2009).

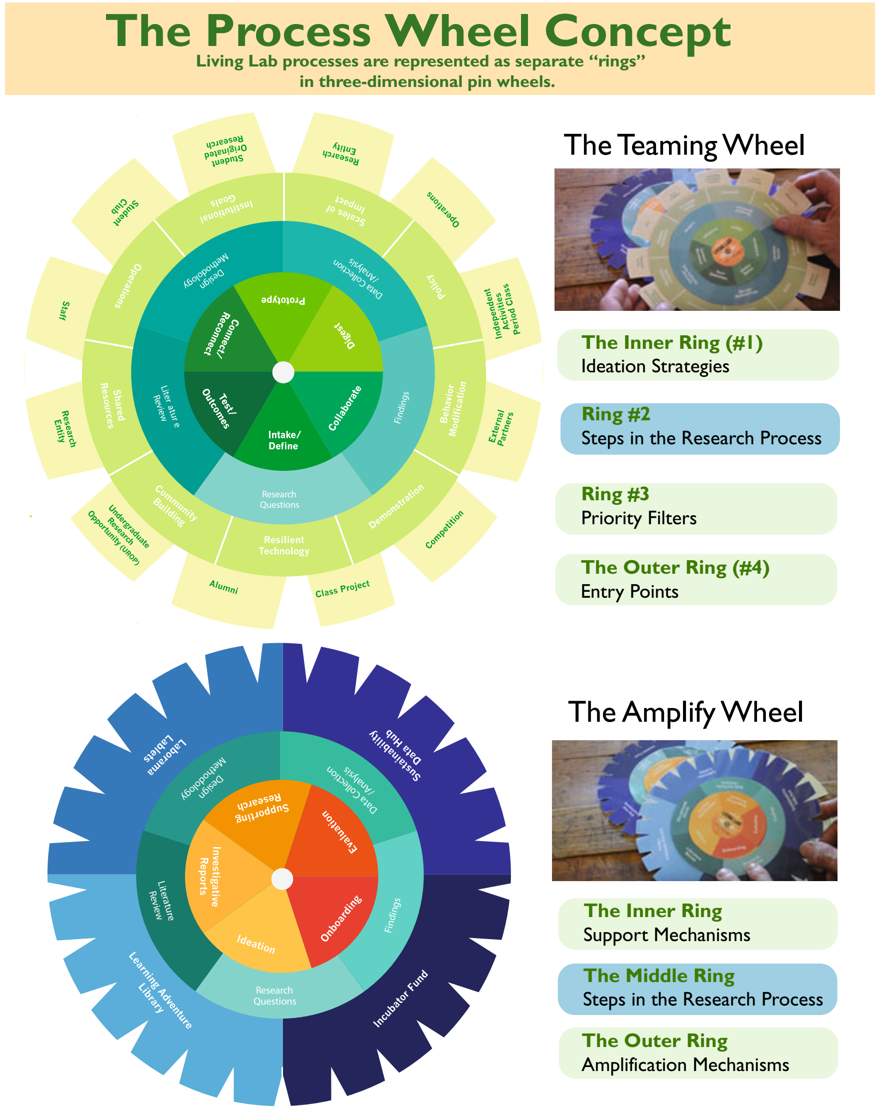

Fig. 1 The *Process Wheels* are designed to facilitate skillful transactions that help to synthesize project team thinking and maximize long-term impacts of research. Each wheel consists of a series of rings attached with a fastener. The rings contain program information associated with processes observed in the cultivation of living lab research. As psychologist Robert Sternberg puts it, one cannot know what one knows in a practical manner if one does not know anything to apply (Sternberg et al. 2008). Original artwork by the author

makes it accessible for the novice and professional (Esckstut and Eckstut 2013). Color wheels often include aspects of color usage throughout history such as perceptual color, optical color, logical construction, and concepts of arbitrary/symbolic color (Itten and Birren 1970). In a similar way, I imagined the *Process Wheels* as a means to make aspects of living lab transactions—that would otherwise not be seen—to be visible, in new ways, as artists and innovators have done throughout history (Lavy 2017).

5 Findings

The *Process Wheels* have been utilized as part of work with real-world projects and included as part of presentations at regional, national and international conferences. The tools help to retrieve multiple aspects of the living lab processes, which may be linear or nonlinear, synchronous or a-synchronous, in nature. Some teams indicated that the tools helped to "facilitate communication with common terms," while others indicated that the tools appeared to help "bridge the communication gap between diverse stakeholders who may have different native languages, cultures, and varying degrees of participation."

Previous scholarship has found that reduced mutual knowledge among team members can often lead to conflict (Cramton 2001), and the *Process Wheels* appear to fill a need among living lab team members to share information. The tools proved useful for managing daily tasks for project managers who must work across boundaries attributed to different agendas and schedules (operational vs. academic), different cultures and languages, and organizational structures (vertical vs. horizontal), while sharing an objective of delivering results and meeting performance targets. Given that the tools increase interactivity, they also impact the degree of emotional connection people have with each other, which could improve team dynamics and outcomes (Neeley 2015). This study takes a step forward by asking the question, How can the project management process be utilized as a team-building activity and improve communications among members who may or may not be co-located?

The top image illustrates the *Teaming Wheel* (Fig. 1):

Inner Ring (#1) identifies ideation strategies, based loosely on design-thinking principles, (Platner 2010) and includes the following nonlinear steps: (a) Intake/Define the Problem, (b) Collaborate, (c) Digest, (d) Prototype, (e) Connect/Reconnect, (f) Testing/Outcomes.

Ring #2 illustrates common steps in the research process (Ravitch and Riggan 2012) that are often linear: (a) Literature Review, (b) Research Questions, (c) Methodology, (d) Data Collection, (e) Findings.

Ring #3 illustrates priority filters that are considerations for determining which research can be supported: (a) Behavioral Modification, (b) Demonstration, (c) Policy, (d) Scales of Impact, (e) Community Building, (f) Shared Resources, (g) Operations, (h) Institutional Goals, (i) Resilient Technology.

Outer Ring (#4) shows various entry points to living lab research: (a) Alumni, (b) Class Project, (c) Competition, (d) External Partners, (e) Independent Activities Period, (f) Operations, (g) Research Entity, (h) Student-Originated Research, (i) Student Club, (j) Staff, (k) Research Entity.

The bottom image illustrates the *Amplify Wheel* (Fig. 1):

The Outer Ring includes devices utilized to generate new research ideas and/or to amplify existing research. At MIT, these devices include my original inventions such as the Learning Adventure Card Library,[2] Lablets,[3] Lab-spects, and the LAB-O-RAMA event,[4] as well as institutional programs (Incubator Fund,[5] the Sustainability Data Hub).[6]
The Middle Ring illustrates common steps in the research process that are often linear: (a) Literature Review, (b) Research Questions, (c) Methodology, (d) Data Collection, (e) Findings.
The Inner Ring defines general support mechanisms for project teams such as Onboarding, Ideation, Investigative Reports, Supporting Research, and Evaluation.

6 The Learning Adventure Card (LAC) Concept

The LAC is a card-based, user-interface system designed to make research more accessible. In appearance, they resemble common trading cards that children and adults collect of their favorite sports players. But instead of logging statistics such as runs batted in, or information about offense, defense, and base running, the LAC records research themes and outcomes such as journal articles, awards, dissertations, inventions, and the creation of new software or companies. One of the more important aspects of the LAC concept is that it is infinitely manipulable. The card format is flexible and functions as a content container that can be scaled up or down depending on how much information is to be included (Babich 2016). This format allows a consistent design aesthetic across multiple devices and thus a consistent experience regardless of the device that is used to access the information (phone, laptop, tablet,

[2]The *Adventure Card Library* (LAC Interface and Knowledge Database) refers to a robust database that contains several hundred data points collected on living lab research (see the section "The Learning Adventure Card Concept" for details).

[3]*Lablets* are those research activities that do not yet meet the criteria for living labs but are using the campus as a test bed. These are typically of shorter duration and effective at quickly testing ideas and research questions. (The act of pursuing these projects is called "lableting.").

[4]The *LAB-O-RAMA* is an annual gathering of academic and operational partners designed to provide a place to tell the stories of living lab research, to show recent findings and technologies, and to make connections for existing or new work.

[5]The *Incubator Fund* is an external donor program with earmarked funding for research using the campus as a test bed.

[6]The *DataPool* is a centralized resource that can collect and store data from disparate sources, enable automation through computer programming, and enhance the analytic capabilities of operational units.

desktop computer). Behind the inviting interface of the cards is a robust database that allows large amounts of structured and unstructured data to be easily accessed, shared, and manipulated.

The LAC concept—which is based on a series of hand-sized, laminated cards—demonstrates several intentional strategies. First and foremost, this concept is a modern-day storytelling device, providing a quick and easy way to acquire lots of knowledge in a vivid and engaging fashion, in which the narrative is the carrier of the message, rather than mere facts (Berger 2015). In pilot tests, it was observed that people wanted to touch the cards, turn them, and run their fingers over the surface, even when unprompted. Thus, a secondary strategy of materiality emerged as a means to reflect one of the inherent characteristics of living labs: hands-on learning. And finally, there was an intentional strategy to understand the goals and motivations of potential users. This discovery process involved asking many questions such as What are the metrics for success? Who is the target audience? Is there a space provided for this journey? Would gamification strategies enhance the experience for users?

The idea for the LAC was inspired by the findings obtained from the listening tour, which indicated that potential users needed help in telling the stories of living lab research in a meaningful and memorable way. The visual similarity of the LAC with trading cards and their athlete-hero subjects was intentional in an effort to conjure sports metaphors (i.e., I call them "baseball cards for researchers"). In this experiment, I combined two unlikely entities, research and sports, in an effort to reduce the distance between research findings and the general public, and to make scholarship more accessible. The cultural magnetism inherent in team sports, then, is being used as a strategy of engagement, borrowed from the cognitive science research field, to engage those who might normally not be drawn to research (Berger 2015) (Fig. 2).

7 Findings

The LAC concept has been piloted at internal, regional, and international events supported by MIT. Cards were displayed as part of tabletop exhibits or as a featured giveaway to attendees who participated in "dot voting" activities associated with living labs.[7] These events included orientation for prospective and admitted students (attended by 63), two pop-up poster exhibits featuring living lab research (attended by 379), two invitation-only conferences focused on sustainability (attended by 168), a global industry event (attended by about 3000 within the software and development industry), and an international sustainability-themed conference (attended by approximately 215).

[7] Dot-voting (also known as dotmocracy) is an established facilitation method used to describe voting with dot stickers or marks with a marker pen. The author utilized dot-voting as a gamification strategy to incentivize input from those participating in themed events.

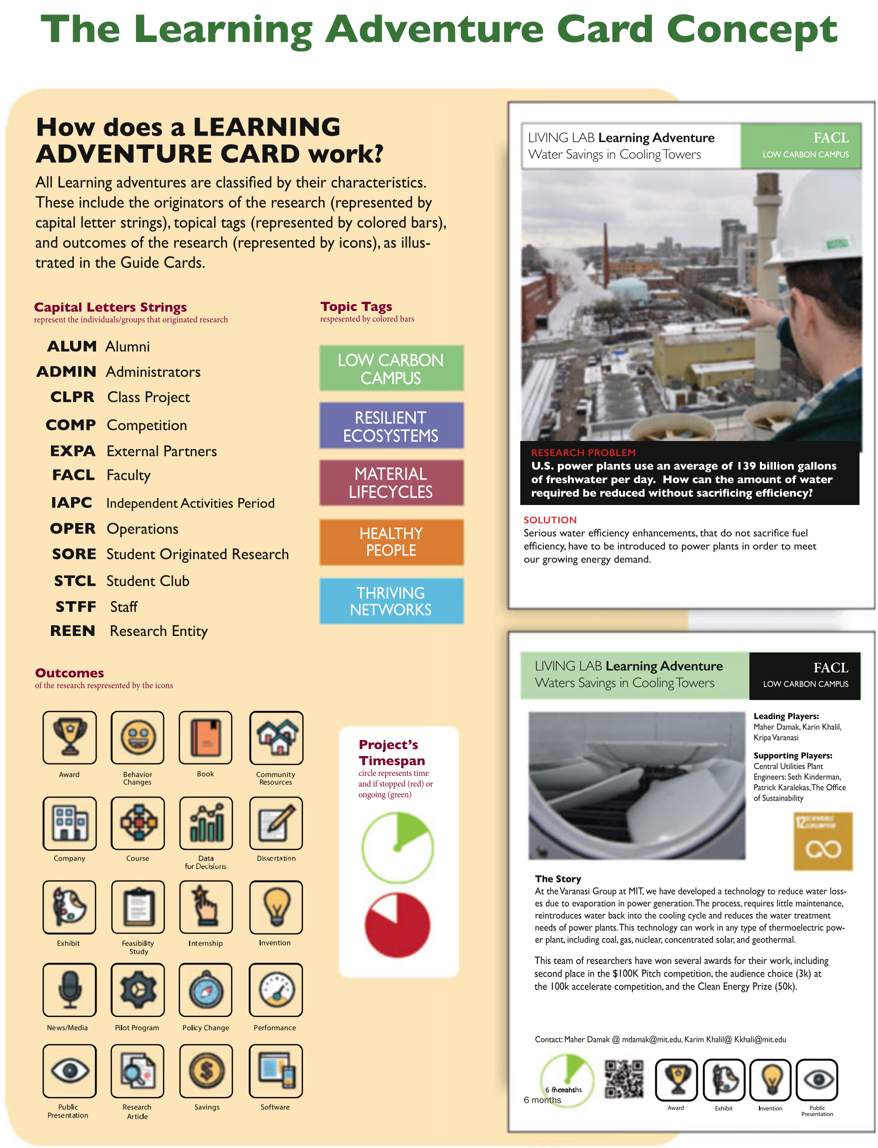

Fig. 2 Information contained on the Learning Adventure Cards is linked to a robust database of structured and unstructured data including information such as outcomes, duration, and sustainable development goals (SDGs). QR codes are used to link to additional information about living lab research. The image at top (right) shows the front of the card, the image at the bottom (right) shows the back of the card. Original artwork by the author

The dot-voting activities polled participants on their awareness of campus-based research, with directions such as “Do you know about this research?” or “What is the living lab that inspires you most?” Surveys were also made available at each event, and 67% of respondents indicated that the cards were effective communication tools, while 42% said that the cards were “highly visual,” and 19% asked about how to “make their own” cards or if they could be automatically printed. Individuals suggested that the cards would be a preferred option to traditional business cards and that they make research “inviting.” In addition, 84% of researchers indicated that the thing they most liked was the link to a database where more information could be searched. There were also positive responses from attendees at international conferences. For instance, international participants from universities based in Germany, Canada, Australia, China, and Croatia reached out to learn how they could participate.

Several ideas have emerged from sharing the cards at these targeted outreach events. The most frequent inquiries were related to scalability issues. For instance, one attendee inquired, “Can this adventure card format be used to capture a whole range of different ways this problem can be addressed—basically, the same research problem but many different examples (or suggestions) of solutions from many different universities? This then becomes a very useful and accessible resource for people aiming to tackle this problem themselves. Therefore, it is not all about researching new solutions but also applying solutions used in one place to somewhere else.” Another recurring question that surfaced with the development of the LAC had to do with the issue of comparing outcomes from living lab research. Most seem to agree that the journal article is the most important outcome for academic research, but how can one assess the relative impact of a journal article with other outcomes, such as obtaining new funding, starting a new company, creating new courses, or the implementation of a new administrative policy? One solution that was explored took the form of a sliding scale (1–100) that was divided into three segments (low, medium, high). Individual outcomes (awards, research article, new funding, new policies, etc.) could be stack-ranked, according to the school’s preference. Thus, the total scores for a given living lab project would all start with a base amount and then the total score for a given living lab project would be dependent on the number of outcomes and the associated ranking of each. However, the decision was made to delete the scoring component from the initial pilot, as it was considered to be subjective and potentially controversial. Future testing and feedback may result in reconsidering the scoring based on consensus of the users.

8 A Vision for a Digital Storytelling Machine

A third innovation tool, the *Living Lab Web App (i.e. the Living Lab Finder)*,[8] is currently in development and manifests the ambition to create a multisensory story-

[8]To view the Living Lab Finder, see https://datapool.mit.edu/living-lab-finder.

Fig. 3 The customized locator map (i.e., the App Map), which contains hand-drawn, stylized, three-dimensional illustrations of campus buildings, is a linchpin of the proposed Web App. This feature distinguishes it from other geo-location apps that rely on the ubiquitous Google Map. Original artwork by the author

telling machine capable of sharing structured and unstructured data in a user-friendly digital interface.

A custom-designed locator map allows users to locate research where it happens and searchable filters allow users to search living labs by initiative types (low-carbon campus, resilient ecosystems, materials life cycles, thriving networks), by sustainability topics (natural language processing creates a word cloud based on an identified primary document), outcomes (awards, dissertations, books, etc.), and duration (Fig. 3). Detail pages include high-resolution images of key aspects of the research, videos and/or audio files, and there is also a search- recommendations engine that identifies related research topics. A list-page view allows users to compare research in terms of the number of outcomes, publications, and duration.

9 Next Steps: Scale, Play, and Weave

The innovation tools described in this study meet the modern expectation of being able to ingest large amounts of data quickly and the opposite desire to linger, explore, compare, and test assumptions. The tools also build on previous scholarship related to the concept of boundary objects, and explore the potential for physical artifacts to bridge between communities of practice (Star and Griesemer 1989). Is it possible to scale these concepts, expand their interactivity, and interleave knowledge from a variety of disciplines to engage a wider spectrum of interest in the living lab phenomena, while intentionally bridging between distinct communities of practice, throughout the globe?

9.1 Scale

When considering issues of scale, it is apparent that a successful deployment of the *Process Wheels*, *Adventure Cards*, and/or the *Living Lab Web App* is dependent on time and resources required to make the devices and use them. The *Process Wheels* and *Adventure Cards* could be made available as a shared resource by the use of universal, "fill-in-the-blank" templates that can be customized for a given institution. Thus, one next step in scaling this idea would be to offer universal templates to other colleges and universities as a shared resource and to study their use, modification, and potential for adoption over time.

The opportunities for sharing the *Living Lab Web App* platform are more complicated. For instance, this tool has already required about $250,000 in external design and development funding.[9] There were also additional costs (time and materials) associated with those involved with the development/approval/testing process during the past year. The customized locator map (a vector graphic tailored to include iconic buildings and landmarks on a given campus) required an additional 230 h of design work to create from scratch. Working together with national or global partners, it may be possible to co-create a version of the *Web App* that shares existing infrastructure, communication, and organizational strategies that could reduce development costs further.

Another next step could be offering the data platform, utilized by both the LAC and *Web App* tools, as a shared resource, or co-creation opportunity for partner colleges and universities, potentially saving significant development costs. A pilot experiment might involve intake of data from selected living lab projects, interested schools, and/or a crafting of a customized *Global Adventure Card* for regional, national, or international users. Future research could examine how the LAC concept translates across geographical boundaries and how the co-creation process may inform communication strategies at scale of the campus, city, and globe.

[9] The Learning Adventure Card Concept was leveraged to obtain over $250,000 in design and development work conducted by a team of data specialists at Intersystems Corporation, an industry-leading vendor for database management, rapid application development and integration, and health-care information, and the Web App Tool was featured at the 2017 Global Summit event in Palm Dessert, California.

9.2 Play

The idea for the *Living Lab Web App* was inspired by the desire to create a digital version of the LAC concept and to appeal to consumers of tools such as Yelp, Craigslist, Facebook, Trello, Twitter, Instagram, Snapchat, and Reddit. Workplaces have adopted internal social tools such as Slack, Yammer, and Chatter or applications such as Microsoft Teams at high rates. In fact, in a study of 4200 companies conducted by the McKinsey Global Institute, 72% reported using them to facilitate communication (Leonardi and Neeley 2017). What if the *Web App* could be refined further to provide a space for both creating content (writing posts, sharing information, or creating documents and videos) and for informal communications that include the act of observing what campus-based researchers are doing and thinking? Currently the *Web App* vision allows users to "like" projects and leave comments, and an automated intake form allows content creation. However, if the interactivity were expanded to include a cultivated reflection activity/game, there would be new opportunities for users to observe others' communications and behaviors, and to pick up bits and pieces of information through time about key definitions, the research process, and emerging frameworks.

Increased interactivity (two-way learning) encourages the borrowing of ideas and solutions and the notion that what a learner performs collaboratively or with assistance can later be performed independently (Vygotsky 1978). Additional research could target the need to understand users' goals and motivations to better understand what inspires them to achieve their goals, and also to understand the root causes associated with representing, learning about, and transforming knowledge among distinct communities of practice utilizing living labs as an innovation strategy (Carlile 2002). Creating a gamified solution that engages people at an emotional level requires a deep understanding of the users, and their goals may not always be rational or easy to identify (Burke 2014). In a similar way, effective communication across functional boundaries, as is required in most living lab work, is equally difficult. It seems important to rethink how motivation operates in a connected world, and how boundary objects, such as the *Living Lab Web App*, can alter current knowledge and create new knowledge, despite obstacles such as scale, time, and proximity.

9.3 Weave

The author deliberately utilized an interleaving strategy within the design of all three tools in an effort to construct knowledge in new ways, and in consideration of an ever more visually oriented culture expecting to access and quickly, easily share information. Future research could integrate findings from other, apparently unrelated fields of study. For instance, given the observed importance of interdisciplinary collaboration, future research could examine the notion of social distance, often applied in business contexts, as a means to understand the team-specific dynamics of communications and engagement and to develop strategies that encourage face-to-face collaboration and build trust and effective working relationships throughout the typical years-long cycle of campus-based research.[10] There appears to be a need to reduce the social distance between the team members and between the ongoing research and the greater community. In fact, strategic business leaders often emphasize the importance of team design, launch, and process management (Swaab et al. 2012), and these ideas could be directly applied by those managing or participating in living lab research.

Perhaps new insights into the proposed innovation tools also may be found by examining the way in which the use of comics has shifted from the back shelves of newsstands into a respected form of culture, as evidenced in celebrated graphic novels (*Persepolis*, *Watchmen*, *Maus*, *Asterios Polyp*), a Tony Award–winning Broadway show (*Fun Home*), adaptations of classic works (*To Kill a Mockingbird*, *The Diary of Anne Frank*), biographies (*March: Book One/Two*), television series (*Our Cartoon President*, *Archer*) and worldwide, blockbuster action movies (*Black Panther*, *The Avengers*, *Fantastic Four*, *Wonder Woman*). One now can even study comics and graphic novels through specialized courses offered at many U.S.-based institutions, and also pursue an accredited undergraduate or graduate degree in the field of sequential arts. Are there ways to apply this powerful form of expression to inform the narratives that are shared on the LACs and the Discover Living Lab *Web App*, or to imagine a new type of immersive case-study format for campus-based research? It would appear that the action-based narrative in living lab research would provide a unique opportunity to choreograph and shape time, as Art Spiegelman (*Maus*) contends (Ball and Kuhlman 2010), or to convey complex ideas and processes through time, with duration, motion, and an "all-at-oneness" (McGuire 2014). Imagine the power of applying Marjane Satrapi's (*Persepolis*) concept of "narrative drawing" to the storytelling process of living labs, in which images are not simply illustrative but part of the storytelling, which requires a degree of completion/participation from the audience/reader. Might this art form help to inspire natural curiosities about the scientific process and the use of the campus as a test bed in real-world environs? Might the intentional use of boundary objects, such as the new tools described herein, help to bridge between participant perspectives, philosophical paradigms and even across varying research methods utilized by those working in living lab realms?

10 Concluding Thoughts

This study of the living lab transactions illuminated challenges in defining terms, identifying opportunities for team building, and communicating the stories of living lab research. But it was the act of combining the observations with the imagination

[10]Social distance is the degree of emotional connection people have with each other. Groups with low levels of social distance feel close and congenial, while those with high levels of social distance face greater challenges in developing satisfying interactions (Neeley 2015).

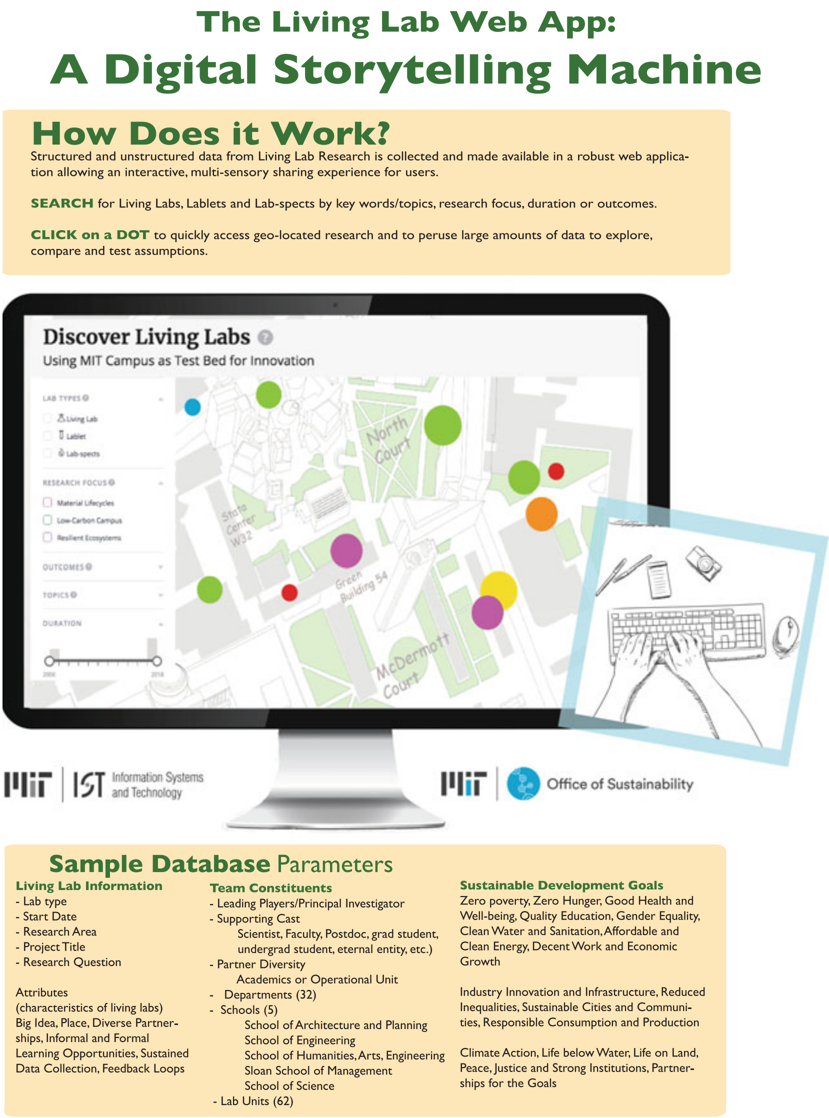

Fig. 4 The Living Lab Web App is imagined as a digital storytelling machine that includes functionalities such as natural language processing, predictive analytics, search recommendation engine, and is accessible via multiple platforms (phone, tablet, web). The Web App is a digital version of the Learning Adventure Card concept, and is inspired by the Urban Living Lab Frameworks (UL3) that I developed to include these specific components: a) Characteristics (big idea, place, diverse partnerships, information and formal learning opportunities, sustained data collection, feedback loops), b) Processes (priority filters, living lab design, research) and c) Typologies (campus to campus, campus to market, market to campus, and market to market) and Definitions (living lab, lablets, lab-spects) . Associated video scholarship may be found here: https://www.youtube.com/watch?v=JU-0MHtrHKw&t=26s

that led to the creation of three innovation tools (boundary objects), described herein, that are inspired by the UL3 Living Lab Learning Frameworks I developed (see Fig. 4). As Leonardo da Vinci aptly shared in his famous tomes, “If you wish to have a sound knowledge of the forms of objects, begin with the details of them, and do not go on to the second step until you have the first well fixed in memory” (Da Vinci and Richter 1970). Da Vinci’s greatest skill was his acute ability to observe things. He wanted to know what causes people to yawn, what makes the aortic valve close, and what that means for perspective in a painting. He taught himself about geology and astronomy, and he pursued many a quirky tangent, such as the tongue of a woodpecker. The study of the living lab phenomena, still in its infancy in North America, seems to require a similar passion for going down rabbit holes that involve distractions, procrastinations, and relentless curiosities in order to find new ways to reduce the social distance between team members in an effort, to bridge between distinct communities of practice, and in pursuit of transdisciplinary approaches to cultivating campus-based research and maximizing outcomes.

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Fostering EfS Connections for Community Wellbeing: Working Meaningfully with What We've Got

Sherridan Emery, Kim Beasy and Bianca Coleman

Abstract The Sustainable Development Goals compel universities to engage in locally relevant Education for Sustainability (EfS) partnerships with communities. In Tasmania, student researchers in education are engaging with schools to support sustainability collaborations in communities. This paper showcases a collaborative community platform that has enabled EfS projects to be co-delivered by the university and local community partners. We theorise the student researcher community interactions from two case studies and offer insights into the ways that student researchers employ cultural capital in efforts to build local momentum for EfS and enhance community wellbeing. The first case study explores a student researcher's entanglements with a school's cultural arts class which took its weekly rug-making sessions into the local community centre. Students taught others how to latch hook a rug, positioning students in a different light—as cultural producers and contributors to their community. The second case study investigates a student researcher led community engagement event, 'Don't Mess with Burnie', which was designed to involve students in taking action to address marine litter. Activities included a beach clean-up, explorations of the water cycle, and found-object art. Through this event school students were empowered to make a difference to the local beach foreshore where they play. Through a discussion of student researcher cultural capital, this paper offers theoretical insights into the 'living laboratory possibilities' of university research and community collaborations more generally.

Keywords Education · Sustainability · Community wellbeing

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1 Introduction

In recent decades, there has been increasing pressure for universities to take an active role in engaging with contemporary issues of local and global scales and become *immersed in* the world (Berman 2008). The Sustainable Development Goals (SDGs), further compel action, in particular Target 4.7 states;

> By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development (United Nations 2018).

Ph.D. candidates are student researchers (SRs) who form a sector of the university population which is growing in size. SRs offer much potential for supporting universities in addressing SDGs, yet we argue that they are a largely overlooked group contributing to actions for sustainability.

Part of the contribution this paper makes is to challenge deficit discourses of SRs which we argue limits their imaginaries of what they can contribute as change agents. We call instead for strength based views which help to realise the potential of SRs as change agents in light of the growing population of SRs in universities globally.

We report on two cases within one university setting (the University of Tasmania) in which SRs led initiatives to engage communities in projects centered around cultural, environmental and social sustainability. These examples showcase the potentiality of SRs as active agents in facilitating action for sustainability. The SRs in these case studies were entangled with a network of engaged sustainability educators through *Education for Sustainability Tasmania* (EfSTas) (a United Nations University Recognised Regional Centre of Expertise in Education for Sustainable Development), which served a linking and leveraging role in which SR capitals could be realised. While the SRs' Ph.D. projects were discrete research projects within the Education Faculty of the University of Tasmania, they were also interwoven with EfSTas as this paper explains.

To offer some context, Tasmania is an island state of Australia, with a rich cultural and natural heritage, including high biodiversity, abundant fertile soil, water, clear air and renewable energy (hydroelectricity) (Australian Bureau of Statistics [ABS] 2006). In addition, Tasmania faces distinctive sustainability challenges associated with remoteness, a weak economy relative to mainland Australia, a historical reliance on exploitative activities (e.g., old growth forest logging, damming and mining), high levels of socioeconomic disadvantage and a low and aging population (ABS 2006). Tasmania's social and political environment makes the state a rich area for experimenting with practice models in the delivery of sustainability education.

In the first section of this paper, we discuss the role of EfSTas for the connectivity of sustainability education in Tasmania and the legitimacy it provides for new projects and initiatives. In subsequent sections, we detail the two case studies, one based on a cultural arts program in a school and the other on an environmental awareness raising initiative. We offer insights into the ways that SRs employ cultural capital to build local momentum for EfS. Drawing upon Bourdieu's (1986) theoretical lens of cultural capital, we develop insights into how SRs can propel agendas of sustainability in local communities. Finally, we explore how the SRs' entanglements with EfSTas opened up powerful opportunities for the SRs to activate and enact their cultural capital in ways which enhance community wellbeing.

2 Education for Sustainability Tasmania: A Regional Centre of Expertise—A Complex Entanglement

EfSTas is a recently recognised Regional Centre of Expertise on Education for Sustainable Development (UNRCE), and here we attempt to make explicit some of the complex entanglements which characterise this network and enables the types of opportunities outlined in the case studies (United Nations University n.d.). Specifically within this account, we focus on the role of SRs in the EfSTas network, while at the same time exploring the dialectic of SRs and community activities using the two case studies.

EfSTas is a collaborative network that brings together the strengths of existing individuals and organisations within Tasmania currently working towards addressing challenges linked to environmental, economic and sociocultural sustainability. Under the UNRCE umbrella, Tasmania is conceptualised as a *living laboratory* to explore ways to work towards sustainability, with education as a central tool. The vision of EfSTas is to advance Tasmania as an interconnected and diverse sustainable island state that is able to adapt and respond to environmental, economic, social and cultural challenges. EfSTas aims to help overcome the sustainability challenges faced by the region, to create a healthier, environmentally and culturally sustainable, and more equitable Tasmanian community. In so doing, EfSTas makes a significant contribution to the global learning space for EfS as an experimental test bed to explore new models of sustainability principles and practice.

The entanglement of EfSTas is made possible by members contributing to mutually beneficial projects under the auspices of EfSTas. The case studies introduced in the next section are indicative of the types of projects facilitated through connections within EfSTas.

3 Methodology

We use case studies (Denzin and Lincoln 1994) as a means of exploring the entangled relations of SRs in communities and in particular to focus on the activation of SR cultural capital. We locate our theoretical positioning as valuing *multiple knowledges*, drawing on the concept of 'an ecology of knowledges' (De Sousa Santos 2007) to value the "epistemological diversity of the world, the recognition of the existence of a plurality of knowledges, beyond scientific knowledge." We contend that De Sousa Santos' call for valuing of diversity encourages activities where the *local* matters. We advance this perspective in our interpretation of SDG 4.7's intention that "all learners acquire the knowledge and skills needed to promote sustainable development" (United Nations 2018). One of the knowledges we focus on (particularly in the cultural arts class study) is that of children's participation in education for sustainability through cultural production (Kuttner 2015). Cultural production is connected with cultural citizenship, which Kuttner describes as "the right and capacity of people to develop and pass on diverse cultural traditions and identities while participating effectively in a shared cultural and political arena."

4 Case Study 1: Weaving *Community Wellbeing* in the Cultural Arts Class

The first case study explores the entanglements of a SR [a co-author of this paper (SE)] with a regional government school's cultural arts class for year 4–6 students. These entanglements included an initiative in which *students shared a cultural practice within their community* and an event in which the *school students were extended an opportunity to share their culture in a professional forum* through EfSTas.

4.1 Weaving the Community Rug (Storying Cultural Experiences as Curriculum)

One of the projects the cultural arts class engaged in over the course of a term was the making of a community rug. The cultural arts program educators, Kathryn and Valerie (pseudonyms are used), made the decision to conduct the weekly cultural arts class sessions in the local community centre. The educators chose to design the rug with inspiration from the patterns of the Preminganah petroglyphs which are significant to Tasmanian Aboriginal people, and the colours of the décor in the community centre at the heart of the students' town.

Each week the students worked on the rug alongside other community members in the community centre. The students taught members of the community skills of latch hooking and felting so that everyone together could contribute to the creation of the rug. This positioned students in a new light, as cultural producers and contributors to their community. A reflective memo written by the SR (SE) after a school morning spent with the cultural arts class is included below:

> We sat around the timber table at the local community centre making a community rug. Five students, a student networker, an Aboriginal artist, a university researcher, and some community centre employees sat together in a circle, latch hooking small knots in a piece of hessian with brightly coloured acrylic wool. Working their latch hooks through the hessian to form each knot, the students created the outlines of the circles that are key features of

> the Preminganah petroglyphs, which were etched into the large rocks on the west coast of Tasmania long ago by Aboriginal people. Over the ensuing month of visits, family members and community centre employees and visitors became part of the rug-making circle, transforming the sheet of brown hessian and acrylic wool into the beginnings of a beautiful colourful rug.
>
> There was an easy conversation that flowed around the table while everyone worked on their respective section of the rug. Some people worked together in pairs. One student showed her mother how to work the felting needle over a felted section of the rug. Students with better latch hooking skills taught people with less developed skills (like me) how to form the knots most efficiently. At the same time, around us mothers (and some fathers) with young children arrived at the centre and children ran off to play in the various play spaces. I noticed that making the rug seemed to create an intentional space which was safe and in which conversations could occur with ease.

This rug-making unit was an arts project designed by the educators to support cultural sustainability. During the SR's participation in the cultural arts program, she supported the educators to connect their program to the Australian Curriculum in the arts, which added 'curricular legitimacy' to this program. The explicit teaching of arts skills and knowledge was part of the program's curriculum, but within a broader frame of cultural wellbeing [which was the student researcher's doctoral study topic], the program was not simply about content and pedagogy. There was intentional skill development being taught: creating the rug provided the structure for developing an array of art skills including knotting (shag and loop pile) and felting techniques. These skills linked with the making and presenting aspects of the Arts curriculum and the fibres strand of the Design and Technologies curriculum (Australian Curriculum Assessment and Reporting Authority n.d.). Students also acquired historical and geographic knowledge about the history of Tasmanian Aboriginal people and the Preminganah petroglyphs on the west coast.

Importantly from a wellbeing perspective, social and emotional learning was supported through rug making at the community centre, through students' engaging with family and community members. Strengthening students' connections to community was an area in which the student networker and artist had identified as a priority for cultural sustainability. With the rug making project, students had opportunities for social interaction and meeting people as they worked on the rug alongside members of their community. In this project students were positioned on an equal footing with other members of the community, positioned as *artists* teaching other family members and community members how to latch hook and how to felt. Through this cultural arts project, students were given the platform to be visible and active contributors to their community.

4.2 Children Leading the Sharing of Culture

During the SR's entanglements with the cultural arts group, the opportunity surfaced to invite the students into a statewide professional learning forum as presenters and cultural leaders.

At the *EfS Tasmania professional forum* in October 2017 the students from the school travelled to Launceston at the invitation of EfSTas to co-present a workshop for Tasmanian educators. The students began by delivering an *Acknowledgement of Country* in palawa-kani, “the revived form of the original Tasmanian Aboriginal languages” (http://tacinc.com.au/programs/palawa-kani/). The Acknowledgement is an important custom of showing respect to Aboriginal Elders past and present and honoring that a gathering is taking place on land which Aboriginal people never ceded and of which Aboriginal people have been custodians for millennia.

During the workshop the school students also led participants in a workshop activity of learning how to make string, sharing the technique they had learned through the cultural arts program using dried and softened river reeds. String making is one of the enduring crafts of Tasmanian Aboriginal peoples in Tasmania (and Australia more widely). Through this initiative of inviting students to present the Acknowledgement of Country and a skills workshop for teachers, the school students were recognized as cultural citizens, continuing the traditions and practices of Tasmanian Aboriginal peoples in a contemporary gathering. This can be viewed as a practice of decolonizing curriculum and reinhabitation of Aboriginal culture in education (Lincoln and González y González 2008).

5 Case Study 2: Partnerships in Community-Based Environmental Sustainability Education

The second case study details a community engagement event, ‘Don’t Mess with Burnie’ (DMWB), which was led by two SRs who are co-authors of this paper (KB and BC). This event was designed to involve children in taking action to address local environmental concerns, including marine debris, pest and problem animal control and recycling and waste management. The Don’t Mess with Burnie activities were conducted over a full-school day and involved over 300 primary school children (aged 8–11 years) and their teachers. The event included a beach clean-up, found object art, participation in science experiments and tours of local waste management facilities. Through this event, school students were empowered to make a difference to the local beach foreshore where they play and to their regional community more generally. Likewise, the hands-on activities also provided professional learning opportunities for teachers. Teachers were able to engage with these activities alongside their students and they discovered how environmental and sustainability education could be meaningfully achieved in their own classroom contexts and local community.

5.1 Burnie as the Site for ‘Don’t Mess with Burnie’

The opportunity for the SRs to facilitate a community engagement event in collaboration with the state government department of education arose when their university offered small-grant funding to promote and encourage connections between the university and schools. The SRs, both having a particular interest in sustainability and environmental education, planned a community-based environmental education project for primary school-aged children in Tasmania's North West city of Burnie (approximately 20,000 people). The SRs were successful in their bid for grant-funding, obtaining approximately AUD $1800 to facilitate the project and to pay for students' transportation to the event. This funding allocation exceeded the SRs initial request, with the University acknowledging the immense value of the event and its role in contributing to an environmentally sustainable future in Tasmania.

Burnie is an area of high socio-economic disadvantage with one of the highest rates of youth unemployment in Australia (Australian Bureau of Statistics 2016). For this reason, the SRs purposefully selected this region of Tasmania to host the event and the schools that participated were those from areas with particularly high levels of disadvantage as measured by their below national-average Index of Community Socio-Educational Advantage (ICSEA) rating, a nationally recognised measure of community social and educational indicators. In addition to the provision of educational opportunities in Burnie, the SRs understood that issues related to the environment and sustainability are of particular relevance to this region. The region's economy strongly relies on agriculture, forestry, manufacturing, mining and tourism (Brindley and Turner 2015). Conservation and effective sustainable management of the environment, therefore, is critical to the ongoing economic prosperity of the region. The event aimed to highlight the roles of individuals, businesses, and the university in ensuring the sustainable use of the region's environmental resources. DMWB was designed to speak to the often-conflicting discourses students in this region are exposed to; that is, economic progress versus environmental protection, job creation versus job loss (Stratford et al. 2003). Additionally, as the event was scheduled during Australia's National Recycling Week, the 'reduce-reuse-recycle' message was at the heart of the day's activities.

5.2 University, School and Community Partnerships

The SRs were particularly motivated to develop positive partnerships between the University, the Tasmanian Department of Education and its schools, local community members and private industry to ensure the ongoing sustainability of the event. Through their affiliation with the University and connection with EfSTas, the SRs were able to connect with a number of enthusiastic classroom teachers and industry professionals who freely offered their knowledge, time and expertise in supporting students to develop their understanding of environmental sustainability. While much of the logistics of the event (e.g. physical space, transportation, organising facilitators, advertising and promotion, liaising with school staff) were organised by the SRs, the successful outcomes of the event were achieved through the collaborative efforts of the SRs, teachers, community members and industry professionals.

To establish these partnerships, the SRs organised a number of web-conferences that brought facilitators and participating teachers together prior to the event. These web-conferences provided opportunities for the teachers to ask questions of the SRs and facilitating community members and industry professionals about how the day would run and the activities/topics that would be covered to help them prepare their students and to plan relevant pre-and-post event classroom-based learning activities.

5.3 Environmental Sustainability Learning in Action

The DMWB event began with an opening address from a Burnie City Council representative which underscored the importance of environmental sustainability initiatives in north-west Tasmania and acknowledged the Plairhekehillerplue People, the traditional Aboriginal owners and custodians of the lands on which Burnie is located and whom for generations have protected, nurtured and sustained its environment. Students then dispersed to participate in a wide variety of participatory environmental sustainability activities through which different classes of students rotated throughout the day. These activities included:

Beach clean-up: West Beach in Burnie is situated approximately 300 m from the city's central business district. It connects the city's main retail and shopping facilities with one of its most popular tourist attractions via a boardwalk built above the foreshore. West Beach is host to a penguin habitat and is a popular beach for swimming and other recreational activities. Pollution, in the form of litter from neighbouring food retailers, assorted plastics and abandoned fishing tackle, is a critical issue at this beach. The beach clean-up activity involved students collectively and systematically scanning a section of the beach, removing rubbish and marine debris, and cataloguing the types of debris that were found and its origins. Through this activity, the students were actively engaged in thinking about and evaluating their community's impact on the coastal environment while undertaking meaningful and achievable action to address the problem. Having cleared a section of the beach of visible litter and debris, students further engaged in discussions with the activity facilitator (a representative from the Tasmanian Department of Education organised by the SRs) about appropriate waste management strategies, recycling, single-use plastics and the impact of marine debris on marine and bird life.

Swap meet: A flea-market style 'swap meet' in which students swapped items such as toys, books and clothing was also organised to enhance and extend students' understanding of the 'reduce-reuse-recycle' message. In exchange for tokens (gumnuts, wooded fruits from the Australian Eucalyptus tree), students brought items from home that they no longer played with or used to share with their peers. At lunchtime and between other activities, the SRs and other facilitators supported students to visit the swap meet to exchange their tokens for the pre-owned items shared by their peers. The swap meet was highly effective in enabling students to see the value of pre-owned toys, books and clothing and in encouraging them to consider more sustainable ways of managing their no-longer needed possessions. The impact of this learning on students' perceptions of pre-owned products is perhaps best highlighted by one school's commitment to undertaking their own regular swap meet activity at school.

Kids teaching kids: The philosophy for this event was underpinned by a belief that a participatory, student-led approach is the most effective and meaningful way for young people to learn about environmental sustainability (De Sousa Santos 2007; De Vreede et al. 2014; Jensen and Schnack 1997). As such, it was a key priority of the event to enable and encourage students to take responsibility for educating their peers about ways that they can adopt a more sustainable approach to their lives. One of the SRs worked closely with a local primary school to support a class of students to prepare a number of short hands-on activities addressing environmental sustainability in their schools. These activities included rubbish and recycling sorting and designing a plastic-free lunch box. These activities not only gave those students who delivered the activities a sense of agency over their learning and leadership in environmental sustainability but enabled their audience of peers to envision ways in which they too can live a more sustainable life.

6 Discussion: Through the Lens of Cultural Capital

In this section, we consider the living laboratory possibilities of SRs through the case studies detailed above. We *think with* Bourdieu's concept of cultural capital as one way of exploring how SRs have valuable contributions to make to broader objectives for sustainable development in local communities. Through this, we hope to draw attention to the potentiality of SRs as agents of change in their communities through their research projects and skill sets. This is a different view to discourses of SRs as needy novice and/or neophyte researchers which are views conveyed in discourses of postgraduate research (Natalier 2011). It offers a more powerful and agentic view of SRs as active in the shaping of their communities. Before moving into the discussion, we offer a brief description of cultural capital (Bourdieu 1986).

6.1 Cultural Capital—What Is It?

Cultural capital consists of social assets that are held or embodied in people. Bourdieu (1986) distinguishes between three forms of cultural capital: embodied in people in the form of knowledge or skills; the objectified state, such as cultural goods, e.g., books, art pieces; and in the institutionalised state such as educational qualifications. Embodied cultural capital requires an investment in time by the person and refers to people's values, skills, knowledge and tastes. Similarly, objectified cultural capital requires access to the embodied cultural capital to use particular objects for their specific purpose, e.g., such as owning a bicycle (objectified capital) but requiring the embodied cultural capital to ride it. Bourdieu's concept of institutionalised cultural capital refers to educational attainment and qualifications and can be viewed as the objective of school settings.

6.2 Reciprocal Relations Between Community and SRs

Working in the community provides a tangible application of student researcher skills in the midst of lengthy individual Ph.D. research projects that are often isolating and abstracted from 'the real-world'. Research suggests that when SRs are engaged in meaningful activities that are related to their research in some way, they are more engaged with their studies and have better wellbeing (Baker and Lattuca 2010; Pyhältö and Keskinen 2012). To see theory in practice, and to see *your* research used and applied in the community is an empowering experience which helps to fuel the momentum for continuing on a Ph.D. journey (Pyhältö and Keskinen 2012).

The DMWB event provided an opportunity for SRs to apply their theoretical knowledge of sustainability engagement in a tangible and practically relevant way. The event was strongly connected with both SRs' research areas and was an opportunity to see how theoretical ideas 'play out' in real time and space, such as children's interpretations of what sustainability means. The event also acted to galvanise SR relationships with key practitioners in their discipline field, such as participating teachers and community organisations delivering environmental sustainability workshops on the day.

It was through SRs' combined cultural capital that they were able to facilitate the event. One SR had previous experience as a school teacher, which meant they had an intimate understanding of what is required for teachers to participate in all-day off-site excursions (e.g. forms, procedures). The other SR had a work history in environmental behaviour change engagement which formed a key asset in constructing the program of the day. In addition, because the SRs were a part of the University, they were eligible to apply for funding to support the event. The SRs provided access to the grant and the skills and expertise in the development of the application, which was successful.

Similarly, the partnership between the SR and the cultural arts educator and students provided opportunities for enhancing cultural capital for all partners involved. The activation of cultural capitals between the SR and the cultural arts educators and students was encompassed within the beneficial relationship which educators perceived as supporting students' cultural wellbeing (Emery et al. 2015).

In this exchange, the cultural arts class provided a tangible location for exploring the concept of cultural wellbeing and considering ways in which Aboriginal culture and broader concepts of culture interacted with cultural wellbeing (the focus of the SR's research). In return the SR offered to the cultural arts class a sounding board; assistance with connecting the enacted curriculum in the class to the ACARA curriculum; opportunities for students in the cultural arts class to exercise their leadership in the community through teaching others valued cultural practices which we argue enhances community wellbeing.

EfSTas afforded the research partnership opportunities for the SR to extend such leadership opportunities outlined above to the cultural arts educators and students. The cultural arts program was designed to enhance Aboriginal students' pride in their culture and their social and emotional wellbeing. Opportunities to present their culture to audiences for occasions including the EfS Tasmania professional forum provided authentic occasions for the cultural arts students to share their achievements and the skills they had developed.

The SR's entanglement with EfSTas afforded the opportunity to invite students from the cultural arts class to teach *teachers* about their aboriginal culture, on their terms, in a statewide professional learning forum. This opportunity for school students to share the experiences and skills they had developed in the cultural arts class was one which the SR could not have created on her own. It came about through the SR's entanglement with EfSTas and was brought into being through the opening made available through EfSTas for the SR to share her research into cultural wellbeing in the EfS Tasmania professional forum.

One aspect of this entangled relation of EfSTas which made this possible was the geographically distributed nature of the statewide forums. The forums travelled around to three main cities/towns in Tasmania. If the EfSTas professional forum occurred only in the capital city (as often tends to happen), the access to *local knowledges* would have been more restricted. The cultural arts group could travel to Launceston to share their learning, but logistically and financially, it would have been prohibitive for the group to travel to Hobart. The distribution of events across the state embodies de Sousa Santos' (2007) call for ecologies of knowledges that value the *local*.

In a similar way, the DMWB event was made possible through the relations within the EfSTas network of people. One SR is an active committee member which puts her in contact with key stakeholders delivering sustainability education in Tasmania. It was only through conversation with the Department of Education representative that the idea of having the event was formed. In addition, the network of EfSTas people acted as a perceived safety-net for the SRs during the organisation of the event. The relationships and combined knowledges of the network made planning the event (including who would be involved in delivering workshops) an easy process. Without this network of support, the SRs would not have taken on lead organising or facilitating roles.

A common feature in both case studies is that local people, local values and local needs were at the centre of the initiatives. We argue that not only does the *local* matter, but that the *locals* who make up 'the local' matter.

7 Conclusion

EfSTas promotes itself as a living laboratory, building upon Tasmania's distinction as an island state that is *a part of* Australia, yet set *apart from* Australia. As a living laboratory, EfSTas is crafting an approach to sustainability education in Tasmania that embraces student researcher community collaboration. As this paper shows, SRs are working hand in hand with Tasmanian communities to activate their own cultural capital and to enhance that of the community members with whom they work, to provide platforms for localised social change on sustainability issues and enter into SDG discourses in Australia.

The case studies outlined in this paper illustrate the potential that SRs offer as an under-realised asset for communities. We suggest that when SRs are provided with the right kinds of enabling platforms, they are able to extend the benefit of their research and growing cultural capital within the community. Through its events and activities, EfSTas is one such enabling platform that affords student researchers a forum for bringing their student researcher cultural capital into contact with the community. The experiences of SRs and community working and learning together demonstrate the reciprocity of partnerships that galvanise around SDGs.

Finally, we have written this paper as a means of contributing to discourses of sustainability in higher education, to offer examples of how collaborations led by SRs can bring together academic and local expertise to create educative moments that contribute toward sustainable development. SDG 4.7 calls for ensuring that all learners "acquire the knowledge and skills to promote sustainable development". We have shown how local knowledges and skills have been at the forefront of the progress being made by a newly recognised Regional Centre of Expertise in Education for Sustainable Development. It is hoped that this paper inspires new ways of considering how student researchers can be agents of change in university contributions towards SDG.

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Adding Value to Open and Distance Learning Programmes in Nature Conservation Through Sustainability Related Work-Integrated Learning

Graeme Wilson and Rudi W. Pretorius

Abstract In response to worldwide criticism that universities do not produce graduates that are work ready, the incorporation of real-world learning experiences in curricula are gradually increasing. Work-integrated learning (WIL) presents one such option and provides opportunity to enhance both education 'about' and 'for' sustainability through the professional and social engagement between students, lecturers and industry. Taking a living lab perspective, this paper reflects on the progress, achievements and challenges experienced during a ten year partnership (2007–2017) between the University of South Africa (Unisa) and the Telperion Nature Reserve to offer quality WIL opportunities to undergraduate nature conservation students. Instead of formal placement at potential WIL providers, ten week-long, work-place based experiential excursions are facilitated by Unisa at Telperion per year. During these excursions students engage with tasks/projects related to sustainability, including amongst others, soil erosion control, alien plant control, *veld* condition assessment and water catchment management. This engagement provides opportunity for student-lecturer interaction in a stimulating milieu during which innovative teaching and learning can be fine-tuned and researched in living lab conditions. In addition to fact-based evidence on participation and success rates, this chapter utilises a qualitative methodology to reflect on lecturer and student experience, the value of a living lab as a learning environment and the realisation of sustainability learning through the Unisa-Telperion WIL programme.

Keywords Work-integrated learning · Open and distance learning · Education for sustainability · Living labs · Nature conservation

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1 Introduction

1.1 The Value of Sustainability Learning: Some Reality Checks

Many examples of sustainability learning in university curricula exist, from adaptations to existing courses to the implementation of new courses (Hopkinson and James 2010), with various pedagogies that are involved (Coral 2009). The consensus points towards the presence of three competency clusters in sustainability learning: strategic knowledge (i.e. creation of future scenarios), practical knowledge (i.e. creation of action–knowledge linkages) and collaborative efforts (i.e. teamwork in different communities) (Brundiers et al. 2010). Ideally, sustainability learning should run side by side with the notion of transformative learning—working towards individual and social change in transformative group learning contexts (Cranton 2016; Larsson and Holmberg 2018). However, several barriers work against this, including curricula that are too full, continued compartmentalisation, the perceived irrelevance of sustainability by some academics and limited commitment to sustainability by institutions/stakeholders (Martin et al. 2006; Molderez and Fonseca 2018).

Over the past decade or so, exposure to and engagement with real-world issues and contexts have increasingly been incorporated in sustainability learning, to the extent that it is now accepted as part and parcel of study endeavours of students in this field (Ibid.). It cannot be assumed, however, that engagement with real-world learning automatically leads to sustainability learning (Wilson and Pretorius 2017). To ensure alignment between real-world learning and competences required from sustainability learning, Brundiers and Wiek (2011) suggest that such opportunities need to:

- focus on actual sustainability problems and/or challenges
- present opportunities for students to apply classroom theory in practice
- facilitate development of workable responses and strategies to sustainability issues
- involve academic supervision as well as collaboration with stakeholders.

1.2 Facilitation of Sustainability Learning Through Work-Integrated Learning (WIL)

The presence of work-integrated components in curricula of university study programmes is becoming more and more common (Abeysekera 2006). WIL, regarded as planned pedagogical interventions between university and the world of work, allows students to gain insight into the realities of their chosen careers and to make theory–practice connections based on the disciplinary knowledge obtained during their studies (CHE 2011). This may lead to opportunities for students to improve understanding of the value of ethical and professional conduct, to explore opportunities to develop non-technical skills and to improve capabilities regarding career self–management (Jackson et al. 2017). Formulated in this way, the potential of WIL to contribute to sustainability learning and thus working towards the sustainable development goals (SDG's—UN 2015) is clear. An added advantage is that WIL is geared towards integration across disciplinary boundaries, thereby creating an ideal milieu for sustainability learning (Wall et al. 2017). Despite this being the situation, scholarship on this potential role, specifically focussing on WIL in sustainability learning, appears to be scarce (Ibid.).

1.3 Aim, Methodology and Value of the Chapter

The position taken in this chapter concurs with Wall et al. (2017) that sustainability learning can be effectively streamlined into certain study programmes with WIL components. This will help to break down disciplinary fragmentation through a unified vision during WIL and directly feeds into SDG 4 (quality education). To support this position, a case study approach is utilised in this chapter to conduct a qualitative assessment of and to critically reflect on the sustainability learning during the WIL programme of the University of South Africa (Unisa) at Telperion Nature Reserve, as part of the National Diploma in Nature Conservation. Special effort is taken to achieve significant depth of assessment in this chapter, which compensates for the limitations usually associated with qualitative research strategies. This chapter links directly to the challenges experienced by Unisa, as an open and distance learning (ODL) institution, to offer qualifications requiring practical and/or industry exposure (Swart 2016), but which can be addressed through appropriate forms of experiential learning such as WIL.

While a previous review of the Unisa WIL programme reflected on a tourist visit simulation (Wilson and Pretorius 2017), this chapter considers the ten work-place based excursions presented each year by Unisa, for nature conservation students in a living labs context at the Telperion Nature Reserve. The living labs paradigm is relevant due to linkages with the creation of inter-disciplinary spaces in which participants engage with sustainability and other challenges (Callaghan and Herselman 2015). The case study approach followed by this chapter facilitates reflection on this WIL programme in terms of its value for sustainability learning, thus addressing the lack of associated scholarly work in this field. Information sources to be used include relevant literature on WIL, living labs and sustainability, the history and timeline of WIL at Telperion (as reflected in conference presentations between 2011 and 2016—Wilson and Wilson 2011, 2013, 2014, 2015, 2016) and critical reflection and assessment by the authors.

Following the introduction, a snapshot of some of the relevant literature on the topic is provided. Thereafter, a review of the ten, week-long WIL excursions offered per year by Unisa at Telperion is supplied; supplemented with a critical assessment of the implementation experience within the context of the living labs approach. A framework of eight criteria for the evaluation of good practice in WIL (Schonell and Macklin 2018) is utilised for this purpose. The conclusion highlights the lessons learnt through presentation of the WIL excursions at Telperion, exposes the potential of WIL to add value to sustainability learning, shows how WIL links with and can benefit from its association with the living labs approach and finally yet importantly, provides some ideas on future work.

2 WIL in the Context of Living Labs for Sustainability

2.1 Linkages Between WIL and the Living Labs Approach

Implementation of living labs at universities is generally regarded as a value adding innovation (Waheed 2017), since it provides opportunities for students to be equipped to understand and to deal with complex issues, to develop skills required by the world of work and to make a stand on moral and ethical dilemmas (Patton 2017). Regarding the teaching and learning mission of universities, living labs provide a framework for students to engage with real-world learning opportunities (Cohen and Lovell 2011), thus providing a link to experiential learning, which includes WIL and service learning (Austin and Rust 2015). In developed world contexts, students typically regard experiential learning as superior (Maranville 2001) as it generates passion and motivates them for probable job opportunities. In poorer, less developed countries, this is not necessarily the case, since jobs are scarce and having an appropriate qualification does not guarantee a job. Of general appeal, however, is that experiential learning provides context, which assists students to understand what they learn, supplies anchor points to recall what was learnt and illustrates how to transfer learning to potential work situations. This corresponds with adult learning theory, which emphasises that learning is more effective when a context for what is learnt, is supplied (Lustbader 1998). However, integration of such learning opportunities into the curriculum is important, and must not merely function as add-ons. Thus, the facilitation of this process can be more meaningful within the living labs framework, than would otherwise be the case.

2.2 Living Labs, WIL and Sustainability Learning

Beneficial from the point of view of sustainability learning is the exposure that WIL, within a living labs framework, provides to students concerning the inter- and multidisciplinary nature of real-world issues and the need to break down silo thinking to deal with these issues effectively (Cohen and Lovell 2011; Annan-Diab and Molinari 2017). In this regard, research findings indicate that students usually appear to be enthusiastic about and would like to have more engagement with real-world contexts through experiential learning, as for instance provided through WIL

(Graczyk 2015). On the contrary, more effort generally seems to be required to obtain engagement by the academic and operations sectors at universities to improve the viability of approaches incorporating real-world learning (Cooper 2017). It has to be pointed out, however, that deliberate efforts are usually required to embed sustainability thinking in experiential learning, which is often characterised by a lack of structure (McPherson et al. 2016) and with the need to consider continuality between subjects and the need to look into problems holistically not necessarily that clear (Johan and Turan 2016). Awareness of these limitations needs to translate into actions to adapt experiential learning practices so as to realize its potential contribution to education for sustainability (EfS) and to feed into support of the SDGs, as presented in the milestone document "Transforming our world: The 2030 Agenda for Sustainable Development" (UN 2015).

2.3 Applications and Examples

Several international charters and declarations concede to the role of higher education institutions in sustainability, including living labs, as a tool for sustainability leadership. An example is the Sustainable Campus Charter, with Principle 3 requiring alignment of the core mission of universities with sustainable development, facilities, research and education to create a 'living laboratory' for sustainability (Global University Leaders Forum 2010). Taking this view, living labs seems to enjoy general acceptance as tool to facilitate experiential learning, which contributes to the relevance of curricula. It is therefore not strange to find that living labs form part of the strategic planning of many universities (Graczyk 2015) and is regarded as one of the options how to integrate teaching and learning, research and operations to work towards increased campus sustainability (Zen 2017).

An example is the University of British Columbia, which managed to introduce one of the most successful living labs to date—created in 2010 with the campus as societal test-bed (Robinson et al. 2013). The University of Manchester is another example, viewing sustainability as part of their broader social responsibility, including cooperation with stakeholders, to develop real-world skills (Evans et al. 2015). However, reports on these as well as on other examples of living labs (i.e. Graczyk 2015), tend to focus on the role of research activities and how campus facilities are utilised, while being less specific about experiential learning. This confirms observations about the lack of scholarly work in this regard (Wall et al. 2017) and accentuates the value added by this chapter to the body of knowledge on WIL and sustainability learning.

3 Case Study: The Unisa-Telperion WIL Programme as a Living Lab for Sustainability

3.1 Nature Conservation Studies Through Open and Distance Learning at Unisa

A basic career in nature conservation entails management of conservation areas, their associated natural ecosystems, habitats and communities in order to ensure the maintenance of biodiversity for the well-being of current and future generations. The challenge faced by Unisa as an ODL institution, is how to offer an academic qualification that prepares graduates for the conservation industry, in which work is very practically orientated, often of a physical nature and conducted out in the field, away from the 'office'. Unisa therefore follows a blended approach for its Diploma in Nature Conservation, consisting of a combination of course work through ODL, practical contact sessions and WIL modules (Pretorius et al. 2016). Through this blended approach, Unisa can ensure that the inculcation of core and/or foundational knowledge and understanding thereof, occurs through work-based applications. In this way curriculum, capabilities and careers are connected in a unique way, as advocated by Thomas and Depasquale (2016).

3.2 The Structure of the WIL Component

In order to make provision for the skills and experience required by the conservation industry, the Unisa Diploma in Nature Conservation includes six, twelve-credit WIL modules—referred to as nature conservation application modules (NCA). Together, these modules account for almost 25% of this 360-credit qualification (Pretorius et al. 2016). Each of the six NCA modules require students to gain suitable experience across seven broad conservation focused themes, namely: animal studies, plant studies, technical studies, communication studies, legal studies, water studies and general or administration studies. Within each of these themes, a list of compulsory as well as elective topics for the compilation of reports are prescribed, which need to be completed and submitted for grading by each student, to assess the engagement of students with the theory and the practical application thereof in a work place context.

Although the WIL component comprises five reports to be completed and submitted for each of the six NCA modules (i.e., 30 reports), significant flexibility is allowed. The requirement is that 10 of these reports have to focus on core/compulsory competencies, while the other 20 can be on elective competencies—selected across the seven conservation-focused themes and based on each student's geographical and contextual situation (Fig. 1). Thus, the curriculum is open enough to allow students to build their WIL experiences based on local contexts, while retaining sufficient structure in their qualification for it to remain relevant for potential employers. In

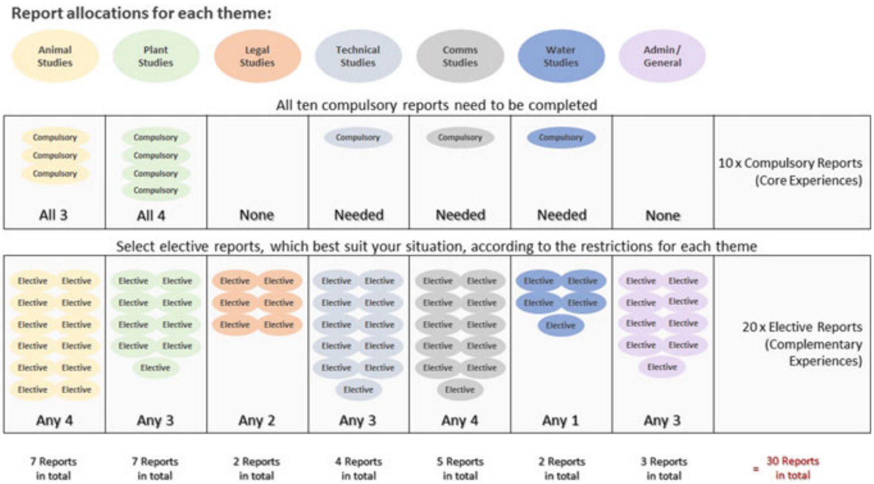

Fig. 1 Compulsory and elective report allocations for the reports requited by the nature conservation application modules (NCA) (© G. Wilson 2018)

addition, students have the option to start with their NCA reports immediately after completion of a compulsory, introductory level one module and contact session, or they can delay working on their NCA reports until after completing of all the theory modules.

3.3 The Relationship Between the Unisa WIL Programme and Telperion Nature Reserve

For many students, the journey to study nature conservation through Unisa is daunting at best. Upon registration, these students need to make decisions on how they plan to complete the WIL component, for which they have to find suitable conservation workplaces to gain the required skills and experience, before they can graduate. As an alternative, the partnership between Unisa and Telperion Nature Reserve (owned by the Oppenheimer family) offers opportunities to students who are unable to find suitable WIL placements elsewhere. The Oppenheimer family provides financial support to assist students with travel and stay-over costs to participate in the WIL excursions presented at Telperion. While Unisa provides support to ensure that all mentorship and skills development activities can take place (Wilson and Wilson 2016). The value of this partnership is that it provides an opportunity for students to complete their qualifications in order to be suitably skilled to able to take up conservation jobs. However, it places Unisa in the unique situation of being the provider of both academic and WIL services.

3.4 More on Telperion Nature Reserve

Telperion Nature Reserve is located in the Mpumalanga Province of South Africa. It covers an area of 7349 ha and accommodates a diversity of game animals. The fact that there are no large predators or very dangerous animals to be found at Telperion, provides students a safe environment to work in and gain the required skills without having the additional stresses associated with providing continual protection for students while they are working in the field. The dominant vegetation is Grassland with large pockets of Mountain Bushveld (Fig. 2), typified by jagged red sandstone rocky outcrops covered in a diversity of tree species. There are numerous freshwater fountains across Telperion, which feed into streams and eventually into a large perennial river, which dissects the reserve. Associated with the presence of this water are well-formed wetlands and deep and densely vegetated valleys. In terms of conservation status, the vegetation type at Telperion is poorly conserved and subjected to alien plant encroachment and soil erosion (Wilson and Pretorius 2017). This fits with the historical use of the area being agriculture and stock farming, while current land use focuses on biodiversity conservation, with related educational and research activities.

Fig. 2 The contrasting landscape between Grassveld and Mountain Bushveld in the Telperion Nature Reserve (© G. Wilson 2013)

3.5 *Engaging with WIL Students at Telperion Nature Reserve as a Living Lab for Sustainability*

3.5.1 Introduction

The partnership with Telperion has enabled Unisa to expand beyond its urban-based campus facilities and to establish a research and education presence at Telperion Nature Reserve. As an ODL institution, this provides Unisa with a distinctive milieu for WIL provisioning. This partnership provides for agreements to initiate and conduct biologically focused research projects within the nature reserve, together with hosting of monthly WIL excursions for targeted groups of nature conservation students. As a 'satellite campus' located in a natural area with free roaming wild animals, this living lab provides several opportunities for research and WIL. While participating in the excursions offered at Telperion, WIL students are guided by a Unisa academic, with a view to develop competencies in sustainability similar to those posited by Brundiers et al. (2010).

Although the topics assigned to each WIL excursion at Telperion are utilised to develop specific skills, students also need to focus on sustainability challenges. These require students to apply their theoretical understanding in practice, thus aligning their thinking and experiences with sustainability perspectives (Brundiers and Wiek 2011). When students are required to focus on a single task but at numerous sites in the reserve, they are exposed to several unique contexts in that particular focus. When multiple topics are offered, the situation differs in that students are required to negotiate the multidisciplinary milieu created by the diversity of theoretical, skill and competency requirements. This speaks to the suggestion by Wall et al. (2017), that WIL presents an ideal setting for sustainability learning. The rest of this section reflects on some of the topics dealt with during WIL excursions at Telperion and shows how sustainability learning is supported in this living labs milieu.

3.5.2 Soil Erosion Control

Soil erosion at Telperion Nature Reserve is mostly of natural origin, caused by game animals using the same pathways on their way to and from water and grazing. These pathways became cleared of protective soil and vegetative covering through the action of the hoofs of these animals. This increases the potential of these pathways to act as rainwater furrows. Left unchecked, these furrows may expand during successive downpours. By reducing the speed of the water within these furrows, the erosive impact of the flowing water can be mitigated.

This can be achieved through creation/placement of water runoff restrictors such as gravel humps or rock-filled gabions (Fig. 3). If positioned correctly, these restrictors are effective in channelling rainwater out of the furrows, so that rainwater is dispersed away from the erosion site. Game animals should be encouraged not to use these susceptible pathways repeatedly, which is achieved by packing thorn-bush branches

Fig. 3 NCA students packing a wire gabion basket with locally sourced rocks to slow down rainwater runoff and in the process rehabilitate a soil erosion site in Telperion Nature Reserve (© G. Wilson 2013)

over the pathways. This allows remedial actions to slow down erosion and for the area to naturally rehabilitate over time.

When arriving at Telperion, most students have very little or no practical experience in soil erosion control, although they do have a basic understanding of the issue, which they gained in their theory modules. When therefore confronted with issues such as slope, gradient, ground cover and soil composition in real-world contexts, the students gain a deeper understanding of the complexities involved with the implementation of soil erosion control measures and all the factors to be taken into account. Considering a contour map in the classroom versus observing the contours of real erosion on site and having to make decisions on remedial actions based on that, provides a very different perspective.

3.5.3 Invasive Plant Control

A variety of unwanted exotic tree species managed to establish themselves throughout the Telperion Nature Reserve, of which one is *Populus x canescans* (Grey Poplar). It is a vigorous species particularly along riverbanks and in wetland areas. The potential of this tree species to form dense and uniform stands in these areas, presents a real threat to the management of the reserve. The Grey Poplar is sterile but reproduces through root suckers (Bromilow 2010). As a result, this species is best controlled through

Fig. 4 NCA students clearing a stand of *Populus x canescans*, which have encroached into a wetland in Telperion Nature Reserve. The student in the foreground is manually removing a young tree while the students in the background are apply herbicides to exposed roots and stumps (© G. Wilson 2015)

mechanical removal combined with application of systemic herbicides. Large trees need to be felled first, with herbicides then applied to the cut stumps. Smaller individual trees can be manually removed together with their roots (Fig. 4). Because of the ability of the Grey Poplar to coppice, control sites need to be visited regularly to remove or re-treat new and re-emerging individuals.

Since encroachment by exotic species is threatening natural biomes in many nature reserves in South Africa, the experience gained by nature conservation students with eradication of the Grey Poplar is invaluable in terms of their future careers. It is also not a matter of simply removing the invasive species, but doing so with consideration of remaining non-invasive species, as well as the general environment (people, water, soil, etc.) which should not be harmed, since herbicides are involved. While textbook knowledge about matters as these are valuable, application in a real-life context confronts students with a range of issues concerning nature conservation which they might not have thought of before, which serves the purpose of sustainability learning in an excellent way.

3.5.4 *Veld* Condition Assessment

Since habitats are in a constant state of flux, vegetation and soil management is critical for wildlife conservation in nature reserves (Van Rooyen 2010). From this viewpoint, it is vital for conservation managers to regularly perform assessments of the condition of the grassland (referred to as *veld* in South Africa). This can be done by ecological indexing, through which a *veld* condition index is determined for an area, thus providing an indication of the health of the *veld*, based on the assigned grazing values of all the grass species present. At Telperion Nature Reserve data for *veld* condition assessment is collected by employing a ‘step-point’ method: With each ‘step’, the tip of the data collectors shoe ‘points’ to a grass species, which is recorded (Fig. 5). After collecting data for a predetermined set of points, the data is used to calculate the condition of the *veld*, based on the numbers of each grass species and their grazing values. This is re-worked to a *veld* condition score, indicating whether the *veld* is in a good condition or not. Based on this, conservation management decisions can be made.

During *veld* condition assessment students have the opportunity to focus on the development of a specialist skill, namely to identify organisms. During field work students learn and practice how to use field guides, which are very different from using textbooks and study guides. Specialist skills as these from part of the experience that students require to function as nature conservationists. This supports sustainability learning directly by showing how specialist knowledge feeds into the bigger picture. Associated with the identification of organisms, is the need to become familiar with specific terminology in order to be able to use species identification keys effectively. These foundational skills take time to develop, but are crucial to master before students will be able apply them in work-related contexts.

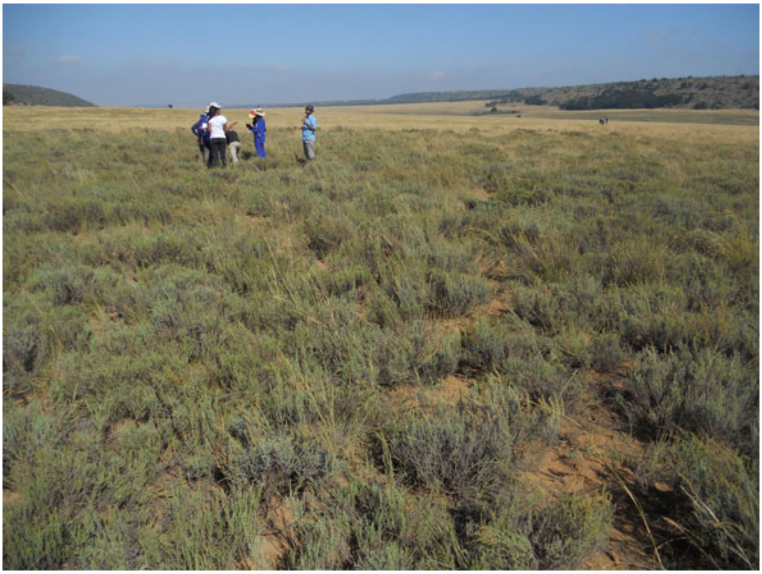

Fig. 5 A group of NCA students using the step point method to collect the required data to determine the condition of the grazing available to the game animals found at Telperion (© G. Wilson 2013)

3.5.5 Water Catchment Management

Related to its relatively low average rainfall, with many South African water resources over-exploited or severely impacted, South Africa is regarded as a water scarce country (Ololade 2018). This poses challenges for the management of conservation areas, of which Telperion is an example. Thus significant effort is required to manage water resources for conservation areas effectively. This includes testing of water quality and monitoring of river health, which is difficult and expensive (Graham et al. 2004). The South African Scoring System (SASS) for biomonitoring has been developed for this purpose, but is very technical. A student-friendly version, referred to as miniSASS was therefore developed, which enables easier monitoring of water quality and river health (Fig. 6). Since aquatic invertebrates vary in their sensitivity to pollutants, the presence or absence of certain order groupings of these invertebrates can be monitored and analysed to make an informed statement on the state of river health and quality of water at the time that the monitoring was conducted.

Students are introduced to miniSASS as a method of biomonitoring within their theoretical studies and are briefly exposed to it practically during one of their contact sessions. However, this limited exposure provides them with the opportunity to learn by doing and distil the competencies required by the industry. When engaging with these students, the limitations of the theoretical and limited practical exposure to the miniSASS method up to that stage become very obvious. Having the opportunity

Fig. 6 NCA students collecting field data in the Telperion Nature Reserve, with the view of being able to create an informed position on the health status of the river under investigation (© G. Wilson 2013)

to apply the minSASS themselves, provides an invaluable opportunity to not only get better acquainted with this method, but also to see how the data and results fit into the bigger conservation picture at Telperion and may contribute to the overall well-being and environmental sustainability of the area.

3.6 Some Reflections on the WIL Excursions at Telperion Nature Reserve

3.6.1 Reflection on Students' Experience

Many Unisa nature conservation students have no work experience whatsoever yet and therefore need to gain the required skills and experience to function in workplace contexts during their participation in the WIL excursions offered at Telperion Nature Reserve. Such students seem to be inclined to credit group work to provide them with the necessary confidence to attempt their WIL module requirements, for which the excursions at Telperion create an ideal milieu. Once exposed to Telperion and how the excursions support nature conservation studies in living labs conditions, many students express the wish to visit the reserve again. Since Unisa offers tuition almost exclusively through ODL, with limited opportunities for face-to-face engagements, the excursions at Telperion have the added value of bringing not only students together, but also to facilitate contact with lecturers. This results in friendships and the formation of student-driven study groups, thus enhancing the quality of learning as experienced by these students. However, the costs involved to attend the excursions at Telperion limit participation. If additional funding can be sourced, more students would be able to engage with the WIL opportunities offered at Telperion.

3.6.2 Reflection on Lecturers' Experience

From the lecturers' viewpoint, the most noticeable benefit of the WIL excursions at Telperion Nature Reserve is probably the opportunity to spend time with small groups of students in face-to-face contexts. Apart from nurturing a working relationship, students seize these opportunities to approach lecturers about academic and WIL related issues they are experiencing difficulties with. This face-to-face contact provides lecturers with insights how their students perceive and engage with their modules. Another positive spinoff is the opportunity for students to master the use of the various pieces of equipment they will encounter if employed in the conservation industry, together with the certainty gained by the lecturers that these skills have been mastered. An added advantage is the exposure of students to the staff of the reserve and to sometimes work alongside the staff, which simulates integration into the industry, albeit briefly, and enables students to refine their soft skills. In the context of the WIL programme at Telperion, this exposure and learning takes place within a student-centred environment, removed from the concern and focus of a fully commercial conservation enterprise. However small these learning experiences are, they are all valuable lessons needed to be learnt, as each student works towards his or her graduation.

4 The Role of WIL at Telperion Nature Reserve as a Living Lab to Facilitate Sustainability Learning

As re-iterated by Schonell and Macklin (2018), no standardised criteria exist to conduct assessments of WIL. Similarly Wall et al. (2017) refer to the lack of scholarship about WIL in EfS. As a consequence, assessment criteria in this regard do not exist, let alone for combinations of WIL, living labs and sustainability learning. Based on evaluative tools developed to gauge the effectiveness and quality of a variety of WIL strategies, Schonell and Macklin (2018) propose criteria for good practice in WIL. This section utilises these criteria as framework to reflect on the role of WIL at Telperion Nature Reserve as catalyst for sustainability learning. This reflection relies on perceptions of the lecturers of their own as well as of student's experiences. To summarise, the progress achieved so far is considered within the context of eight elements for adoption of a living labs approach for campuses as identified by Cohen and Lovell (2011).

- *Institutional embeddedness*: Good practice requires WIL to be embedded across various curricula, backed by management and integrated with community engagement. The WIL component of the Diploma in Nature Conservation is offered in the framework of the WIL policy of Unisa, with numerous implementations across the university. Management backing is evident through the persistence to offer WIL at Unisa, despite the lack of governmental funding in this regard (related to the expectation that WIL is facilitated through placements in industry). Regarding embeddedness of WIL in community engagement at Unisa, more opportunities can still be explored, also for the Diploma in Nature Conservation.
- *Relationships*: WIL has to be beneficial for all stakeholders, guided by ethical and legal responsibilities and supported administratively by the university. This is addressed through the Unisa-Telperion partnership, which assists nature conservation students to complete their WIL requirements. Within four years of initiation, this partnership was indeed in the position to develop and provide the nature conservation sector required skills (Wilson and Wilson 2011). Since implementation in 2011, the graduation rate of students for the Diploma in Nature Conservation has improved consistently (Wilson and Wilson 2015). This correlates with the facilitation of WIL excursions by Unisa and academics assuming the student mentorship role. Mutual benefit manifests since the students obtain workplace-based insights, while Telperion gains the fruits of the student's time and efforts on the reserve.
- *Student preparation*: Before engaging with WIL, students need exposure to the required theoretical knowledge and skills to perform in the WIL environment.

They also need to have a clear understanding of WIL practice and have established clear goals for the planned engagement. The theory and practical modules, constituting 75% of the modules for their qualification (Pretorius et al. 2016), provide adequate opportunity for Unisa Nature Conservation students to prepare for the WIL excursions at Telperion. Moreover, the design of the WIL modules includes reporting templates that enable students to highlight their goals for WIL, assist them to reflect on their experiences and in turn to improve their assessment submissions.

- *Supervision*: Supervisors need to be available to guide students through the WIL component. They can come from universities and/or from WIL settings and can serve as points of reference/oversight to provide feedback on learning, professional practice and personal support. In the Telperion scenario, academics take the role of sector located supervisors. This removes uncertainties about consistency in supervision quality. Students gain through the exposure to and fine-tuning of competencies. At the same time they obtain oversight and feedback on concepts they are grappling with. Since academics are involved, students also receive guidance regarding professional and personal development.
- *Learning outcomes*: Benchmarking against good practice indicates that learning outcomes for WIL programmes need to cover professional standards, capacity building (emotional intelligence, citizenship, self-confidence, etc.) and workplace attributes (cultural awareness, thinking skills, problem solving, etc.). The WIL modules offered by Unisa for the Diploma in Nature Conservation were developed through participatory engagement with the conservation industry. Therefore, the most current and pertinent sector related knowledge, skills, competencies and workplace attributes were blended with the academic outcomes, so that the requirements specified by this criterion are almost fully complied with.
- *Curriculum*: Aspects as participation in authentic learning activities that matches the real-world workplace complexities, skills and attributes are central to a curriculum geared towards WIL, with inclusion of activities that facilitate learning to and from the WIL experience. With the ten week-long excursions offered to WIL students at Telperion, most of the WIL curriculum is covered, which builds the students situated knowledge, understanding and practical competencies. The responsible academics, having an acute understanding of the curriculum, are ideally positioned to facilitate the integration and alignment of theory, practice and competency development amongst participating students.
- *Pedagogies*: The pedagogies employed in WIL programmes require a strong element of mentoring to achieve alignment and integration of theory, practice and skills and therefore need to be inquiry- and scenario-driven in order to build cognition and practical wisdom. The WIL modules offered at Telperion subscribes to inquiry-based, active learning as a strategy to engage students, which is a proven vehicle to enhance the sustainability consciousness of students (Kalsoom and Khanam 2017). In this regard, the design of the assessment strategy for these modules plays an important role. Strategies such as working in small-groups, role-play and data collection and analysis are used to get students motivated and

interested, while simultaneously working on their skills to think critically, solve problems and function in different social contexts.
- *Assessment*: Since assessment is regarded as an important driver of learning (Sainsbury and Walker 2008), it should also be integral to WIL programmes. An added requirement is that assessment needs to reflect workplace complexities, the experiential nature of learning, professional and reflective practitioner skills and abilities to integrate theory, experience and practice. In the Telperion scenario, the active involvement of the participating academics in the mentoring of WIL students permits continuous assessment of the student engagements with the focus on whole student development (Wilson and Wilson 2013). When gaps are observed in the theoretical or practical understanding, the attending academic is suitably located to use this situation as a teachable opportunity.

To conclude this reflective section on the role of WIL at Telperion Nature Reserve to facilitate sustainability learning, it is clear that some of the elements for the adoption of a living labs approach for campuses (Cohen and Lovell 2011) are indeed in place. However, not all of these elements will necessarily feature very prominently at Telperion and its conservation campus, which functions as a "satellite" facility and not a fully fledged campus. Despite this constraint, the comparative assessment of these aspects is beneficial as this assists with identification of aspects that are on track, versus those that might be considered for attention. In view of the preceding assessment in Sects. 3 and 4 of this chapter, aspects that can be regarded as on track at Telperion include: Element 4—Integration into the curriculum; Element 6: Build partnerships with industry. Aspects which have been included, but in a limited way due to the focused nature of the conservation campus at Telperion include: Element 1: Engage the right campus participants; Element 2: Identify key programs; Element 5: Expand beyond individual programs of study; Element 3: Build credibility through engagement and data. Aspects not dealt with at all at Telperion or in a very limited way relates to engagement with and involvement of communities at various levels and include: Element 7: Engage support beyond the campus; Element 8: Open the labs to the community.

5 Conclusion

5.1 *Value of the WIL Excursions at Telperion Nature Reserve*

The WIL programme hosted at Telperion Nature Reserve offers Unisa's ODL students the possibility to obtain credits for the work-based requirements of the Diploma in Nature Conservation. At the same time, face-to-face interaction between students and students and between students and lecturers is allowed, which usually does not form part of the ODL experience. Access to a conducive WIL environment provides lecturers opportunities to fine-tune and do research about teaching and learning within the context of a living lab for sustainability learning. Over its ten-year existence, the

Unisa-Telperion partnership proved that it is indeed possible for a university to offer WIL experiences for nature conservation students.

It has been demonstrated, although based only on reflection from the lecturer's point of view that these WIL engagements contribute greatly towards getting students work-ready through exposure to real-world learning experiences (Wilson and Wilson 2016). Students work, learn and build their experience in a safe and student-friendly environment, while receiving guidance from their lecturers. This allows them to gain confidence and a better understanding of the WIL component of the curriculum. They also benefit from engaging with the reserve staff and management while they are practicing sector embedded skills and knowledge. In order to add more depth to this research, the next step is to obtain insight regarding student perceptions on the WIL sessions offered at Telperion, which can be used to make changes or redirect attention where necessary.

5.2 Potential of WIL to Add Value to Sustainability Learning

As a functioning nature reserve, Telperion provides an enabling environment for the nature conservation students who participate in the WIL excursions to develop and test workable responses and strategies to real-world sustainability issues. This is achieved in a collaborative, team-work context and is guided/mentored through the actions of the supervisors and through the support of academics and sector stakeholders. In this way the three competency clusters for sustainability learning (Brundiers et al. 2010) namely practical knowledge, collaborative efforts and strategic knowledge, are addressed to a varying extent and through various ways and means. The multiple conservation topics, which students are confronted with during the WIL excursions to Telperion, require of them to develop and hone their strategic and practical knowledge in order to address and complete the set tasks satisfactorily. Additionally, these tasks require students of different gender, age, language and cultural backgrounds to collaborate if they are to succeed. The tasks which are set, focus on actual sustainability problems and/or challenges, and therefore present the students with real work place opportunities to apply what they have gained from their engagement with classroom theory.

5.3 WIL as Living Lab for Sustainability—Concluding Ideas and Next Steps

The conservation campus at Telperion Nature Reserve, which provides opportunities for WIL and research, is an example of a satellite facility of a higher education institution, and which functions as a living lab for sustainability. The uniqueness about the Unisa-Telperion WIL partnership is that it brings together an ODL institution and a highly distinctive vocational industry. In this way, a new perspective on the living labs approach is provided. This WIL partnership encourages and facilitates sustainability learning, WIL and service learning in a unique way. Additional multi-disciplinary collaborations with Telperion can be considered, through which exposure of WIL students to world of work opportunities can be expanded. The potential for EfS is vast, especially in terms of the aspects which are only partly or not yet fully addressed at this stage, such as community engagement/outreach, expansion beyond individual study programs and building credibility through engagement and data. Increased management buy-in would be required to support the continued involvement of Unisa with the WIL excursions which are offered at Telperion and to facilitate the continued integration of sustainability thinking and WIL within an ODL context.

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Cultural-Based Education of Tamansiswa as a Locomotive of Indonesian Education System

Cahyono Agus, Pita Asih Bekti Cahyanti, Bambang Widodo, Yuyun Yulia and Siti Rochmiyati

Abstract A World Bank Report (2013) found that Indonesian students are at the bottom on TIMMS, PIRLS and PISA tests, brings Indonesian education index was categorized as the lowest ranking. Thus, Indonesia must do a restoration or revolution by considering local cultural aspects. Ki Hadjar Dewantara (KHD), founding father of Tamansiswa institution, proposed concept of Three Education Centre (*Tri Pusat Pendidikan*), namely, family, school and community. The education system with strong culture and humanity values educate head, heart and hand respectively. Accordingly, "*Trilogy* of leadership" in front to be the model, in the middle to raise the spirit, behind to encourage. Indonesian education revolution for 89.48 million children is urgently done to participate on dignified sustainable development. Indonesian education system needs to provide intelligent, wide, deep, creative, innovative, integrated, comprehensive and futuristic concept that foster responsibility and real contribution in 100 years Indonesia independence day, 2045.

Keywords Character building · Edutainment · Golden generation · Leadership · Tamansiswa

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1 Introduction

We are currently living in the world with mental damage and disruption in all fields. Chris Hedges, a senior journalist from USA noted that living in such condition where doctors ruin health, disruption of justice undermines legal system, disruption of higher education spoils knowledge, disruption of government smashes up freedom and authority, disruption of newspaper and social media ruins public information, fanaticism decreases morality. To solve such problems, Nelson Mandela noted that education is the best weapon to change a better world (Anonim 2017; Agus 2016a, 2017, 2018).

However, education system face the worst fact in which four international surveys put Indonesian education in the lowest rank. The Learning Curve ranked Indonesian in the bottom. Organization for Economic Co-operation and Development (OECD) nominated in the 64th out of 65 countries, and in the 40th rank out of 42 based on TIMS and PIRLS. Moreover, World Education Forum managed under United Nations put in the 69th from 76 nations whereas World Literacy ranked 60th out of 61 countries. United Nation Educational contended that merely one (1) of 1000 people was able to have good reading motivation (Anonim 2017; Agus 2016a, 2017, 2018).

The test selection or Ujian Nasional (national examination) for kindergarten, elementary, and secondary schools does not seem to make them becoming good learners. Students who takes national examination in Yogyakarta were depressed, taking short cuts, cheating, corruption, grade orientation, substance loss and integrity. Students cannot integrate cultural and humanitarian values. Schools mean heavy, difficult, scary, and boring. Yulia (2014) in her research underlines the aim of teaching English is to passing the national examination, not to achieve student communicative competence. The examination tested students' knowledge not creating a meaningful text (discourse competence) as highlighted by Celce-Murcia et al. (1995).

Students are separated with cultural values and humanity, thus they become easily tempted to play games and entertainment that make them happy. In other words, technology that is fun make them addicted. Likewise, the rampant at the beginning of the lesson actually makes a vengeful individual, violent, ego, not respect; therefore, they might later become leaders of the nation who can be arrogant and want to win his own (Agus 2016a, 2017, 2018).

Indonesia must undertake the restoration (renewal, revolution) of education by re-discovering the "*khithah*" (back to nature) of the appropriate national education system which provides intelligent, broad, profound and futuristic insights (Agus 2016a, b, 2017, 2018). It, therefore, fosters responsibility and contribution in realizing a sustainable, dignified, and sustainable environment. It is supposed to be strongly rooted in their own culture with contemporary reforms, and refers to an educational system that is fun (edutainment) and emphasizes cultural values and humanity that has been coined by Ki Hadjar Dewantara when establishing Tamansiswa in 1922 in Yogyakarta (Widodo 2017).

2 Materials and Methods

This research includes the type of literature study (library research), with the search data obtained from literature materials both in the primary and secondary sources. Historical study method is used to collect data about Ki Hajar Dewantara educational concept as embodied in the principles of Panca Dharma. The thematic study method is used to describe data about current and future educational issues and concepts that become an analytical tool to see the conception of noble teachings of Ki Hadjar Dewantara and Tamansiswa. The data analysis was conducted by comparative, analytical, and synthesis method.

3 Golden Generation in Indonesia

"Golden generation" have competence, character, lifestyle, religious values and great spirit. They should have good attitude, mindset, concept and superior civilization with insight that be smart, broad, deep, productive, creative, innovative, and futuristic to foster responsibility and real contribution in realizing a healthy, peaceful, dignified and sustainable environment and life (Anonim 2017; Lasmawan 2017).

Indonesia demographic bonus occurs between 2012 and 2035. Based on Central Bureau of Statistics 2011, the number of children aged 0–9 years reaches 45.93 million, while children aged 10–19 years amounts to 43.55 million people. These are the 2045 golden generation who must receive excellent education. The early childhood group of 0–9 years is the golden age of a child, so it becomes a very important period in the physical and mental development of a human being (Anonim 2017; Lasmawan 2017).

Students of golden age in Japan are more taught ethics, morals, culture, independence, discipline, responsibility, that is in line with the students' development without any excessive burden of reading, writing and mathematics lessons. There is no test from first to third grade, as the goal of education is to implement the concept and character building. Finland was put in the first rank in the World Global Education because the education system requires short school hour and no homework with the meaning in every learning process. This is very different from the current Indonesian educational orientation that pursues grade only, ignoring the meaning of education itself (Agus 2017, 2018).

According to Kanter (1997), future generations will be dominated by cosmopolitan thinking (Agus 2017). They need to have 4C, namely: concept, competence, connection, and confidence to give inspiration, initiation, and motivation. Stanley (1997) points out that out of 100 factors that affect a person's success, IQ is only ranked 21st, attendance at a favorite school is 23rd, and graduating as best in class is just the 30th factor. He further concluded that the first 10 main factors are: honest, disciplined, skilled, family support, hard work, loving work, leadership, passion and competitive personality, life management, and selling skills ideas and products (Agus 2016a, b, 2017, 2018).

4 Local Culture as a Basic for National Character Building

Javanese and other local songs revealing great values can shape good character of Indonesian children. These songs are short, and have simple lyrics that is in harmony with the psychological level of children. The songs are a means of children to have fun in class and outside class either in school or home. Javanese children songs are unique and interesting because children who still love to play, chat and talk happily. As well, they contain moral values that are influential to children's character (Agus 2016a, b, 2017).

The concept of edutainment, which conveys the element of entertaining has long been applied to Tamansiswa colleges founded by KHD since 1922. The process of internalizing educational messages in children's *dolanan* (games) flows automatically in every lyrics and reflected and manifested in the speech and child's daily behavior. However, the Javanese children's songs get less attention from the government and related institutions. In the end, the children and parents are now less familiar with Javanese children's songs.

Law no 13/2012 about Yogyakarta as the special province is based on 3 basic values: *Sangkan paraning dumadi* (the origin of life), *Hamemayu Hayuning Bawono* (glorify the earth) and *Manunggaling Kawulo Gusti* (the union of man and god). Yogyakarta must be able to realize the welfare of all living creatures, both human, animal and plant. The Yogyakarta renaissance initiated by the Governor of Yogyakarta, is aimed at creating a superior new civilization that produces the main Indonesian human who have sense of deity, humanity, and justice. Culture should be able to be a locomotive of health development, education, economy, citizen protection, food, tourism, technology, energy, layout and environment that make prosperous all living creatures (Agus 2016a, b, 2017).

The main source of knowledge that is deeply rooted and influenced Jogja consisting of 5 sources, namely *Kraton* (kingdom), *Tamansiswa* (nationalism), *Muhammadiyah* (modern religious), *Pesantren* (traditional religious), and general education. Yogyakarta as the concept of Education for Sustainable Development can be gained through education (formal, informal and informal) to build universe as effective powerful instrument for communicating, providing information, awareness, learning the masses/communities, and moving the nation toward a sustainable future life (Agus 2016a, b, 2017). This concept inserts insights and concepts intelligently, extensively, deeply and futuristically about the global environment by giving people the awareness and ability (especially of future generations) to contribute better to sustainable development in the present and future.

Ki Ageng Suryomentaram points out there are levels of *Hamemayu Hayuning Sariro* (private level), Nation (national), *Manungsa* (mondial), *Bawono* (universal). The concept of *Hamemayu Hayuning Bawono* itself consists of *Hamemayu Hayuning Wono* (forest and plant), *Sato* (animal), *Tirto* (water), *Bantolo* (earth), *Hawa* (atmosphere), *Samodro* (coast and sea), *Manungso* (human), *Budoyo* (Culture), and *Projo* (state). Empowerment of land resources (land, water, minerals, air, and so on), biological resources (animals, plants, humans and other living things), and environmental resources (interaction between creatures), must be synergistic and optimal (Agus 2016a, b, 2017). The new paradigm of Yogyakarta returns to ZERO, in the close relationship among God, human, and nature by empowering all elements of the earth, harmonious and balanced. The cycle of nature, life, culture, soul, body, energy, water, materials and money need to be managed in an integrated and sustainable way to gain economic, environmental and socio-cultural value (Agus 2017, 2018). The breakthroughs, synergies and innovations of the new civilization that are the result of the re-digging, find the recognition and re-realization of a culture that had been neglected due to modernization. The empowerment of information technology (IT) drives Yogyakarta into Cyber City.

5 Excellent Paradigm and Value in Tamansiswa

Ki Hadjar Dewantara proposed *Tri Pusat Pendidikan* (Three Central of Education) that becomes the center of education. National Law no. 20/2003 formulated into *Three* Education Center—family, school and community. The among system, method of teaching and education based on love, care and dedication should be developed. Being independent, human being can develop all aspects harmoniously. They can respect moral value of everyone (Agus 2016a, b, 2017). Thus, Ki Hajar Dewantara coined proverb "educate the head, the heart, and the hand".

Among system comes from Javanese language, *mong* or *momong*, which means parenting. The teachers or lecturers are called *pamong* meaning to educate and teach students with affection. *Momong*, *Among*, and *Ngemong*, contained a very basic value, that is, education is not forcing but it does not mean to let children develop freely without direction. *Among* method has understanding of keeping, fostering and educating students with affection (Agus 2016a, b, 2017).

The *Among* system is often associated with the principle and concept of "Trilogy of Leadership" consisting of *Ing Ngarsa Sung Taladha* (in front to be a leader as well as a model), *Ing Madya Mangun Karsa* (in the middle to build spirit), and *Tut Wuri Handayani* (in the back to encourage the parties s/he leads) (MLPTS 2012). This concept becomes a spectacle jargon with no guidance at all. This nation has experienced decadence of cultural values such as leader fails to give example, corruption, criminal, immoral, and so on. Consequently, the character education need to be initiated—education based on noble cultural values.

Someone's attitude and behaviour should not be individualistic, but must be beneficial to themselves, nation, and the world. In the modern education today, the concept of mental *trisakti* can be harmonized with the effort to facilitate students in the learning development including cognitive aspects (knowledge/understanding), affective aspects (attitudes or interests), and psychomotor attitude (skills) (Agus 2017). In fact, Yulia (2014) concludes that classroom instruction has traditionally concentrated on cognitive development; the learning strategies emphasized on memorization and repetition. This is in line with Bjork (2006) finding that there was no significant change in behaviour in such desentralized system. Added with this Coleman et al. (2004) points out that policies bring considerable confusion and it is continuing.

6 PANCA DARMA (Five Principles of Tamansiswa)

In the fifth Tamansiswa congress in 1947, the seven principles of Tamansiswa of 1922 were changed into five principles referred to as Tamansiswa's Principles of 1947 or *Panca Darma Tamansiswa* (five pillars of Tamansiswa) including: (1) Natural character, (2) Independence, (3) Culture, (4) Nationality and (5) Humanity (MLPTS 2012).

The first principle of natural character relates to human nature as living being inseparable of God-created universe. Human must always regulates and positions his or her existence in harmonious relation with nature and surrounding environment (MLPTS 2012). The harmonious relation will support the effort to pursue prosperity, but when there is a conflict, it will result in the destruction of human dignity. Therefore, education must be designed in a way that it gives a harmonious relation and cohesion of human and nature (Solehan 2010; Wahyudi 2007; Agus 2017).

Concerning with the principle of independence, it is considered as God's gift for human along with "rights to regulate him- or herself" (*zelfbescheikkingsrecht*) keeping in mind that there are orderliness requirement for peaceful social life (MLPTS 2012). Therefore, it must be considered as "self-discipline" on the basis of noble living values both as individuals and members of a society. It must be a foundation in the development of strong personality with awareness of balanced and harmonious atmosphere with society (Macaryus 2009, 2010; Agus 2017).

The principle of culture means that there is a responsibility for preserving values and various kinds of national culture (MLPTS 2012). It is important to make any possible effort in developing it by considering intelligence of the recent era and also global advancement for the shake of both physically and psychological well-being of people in every era and situation (Macaryus 2009, 2010; Agus 2017). Thus, the principle of culture and its development are dynamic in nature and does not represent static defense. The culture supposed to be developed and maintained includes everything related to the living interests of a nation in both physical and psychological areas.

The principle of nationality means that every nation in this globe loves and upholds its state and national bonds for the purpose of achieving both physical and psychological happiness of all of the components of the nations (MLPTS 2012). It should not be on the contrary to the principles of humanity and unity as capital in gaining national success so that it does not result in hostility against other nations. The principle of humanity means that it is human service coming from noble reason. The noble reason results in compassion for both fellow men and universe (Macaryus 2009, 2010; Agus 2017).

6.1 Tri Sakti Jiwa (Three Excellent Soul)

The cultural concept of "Tri Sakti Jiwa" ***(Three Excellent Souls)*** taught by KHD consists of *cipta* (create), *rasa* (feel) and *karsa* (intend). These describe reason, emotion, and intention, respectively . The concept represents three human necessary psychological powers that must be in a good combination. The lack of any of the three powers will result in failure. Therefore, a good balance of the three powers becomes the determinant factor of the success in achieving education objectives (Dewantara 2013a, b).

The reason is useful KHD or human in finding truth and falsehood through experiences and that has active and subjective imagination power to act on his or her own intention and in independent manner (Agus 2017). Thus, human does not merely follow others' instructions, recommendations, and pressure though he or she may wisely consider the instructions, the recommendations and the pressure.

Emotion is heart drive that results in human willingness or unwillingness, happiness or sadness, shame or pride, satisfaction of disappointment, braveness or fear, anger or compassion, hatred or love that may be wholeheartedly felt that does not need the involvement of reason. Concerning with the emotion human tends to be passive. However, human may also be reactive in achieving emotional unity so that physical sensation namely five senses may have the same feeling as the psychological one (Agus 2017).

The intention is the power resulting in reasoning and emotional exercises. Also, it is the extension of natural desire in human psyche, but it has been considered by the reason and the emotion so that it was no longer purely "*instincten*" as manifested in low and rough drives. It represents the antecedence of all of human actions that are noble in nature. The unity of the reason, the emotion and the intention represents human noble character. The three human psychological powers were the prerequisite in materializing the idea of civilized and virtuous social being (Dewantara 2013a, b).

Ki Hadjar Dewantara intended to: (a) position students/learners in the center of education process, (b) consider education as a dynamic process, and (c) put the emphasis on the balance of the reason, the emotion and the intention of the students/the learners (Surono 2010; Subagya 2016). Thus, the education must pay a good attention to the balance of the reason, the emotion and the intention in education so that the education is not merely the process of transferring knowledge, but the process of the transformation of values (Agus 2017).

7 Character Education

One of the characteristics of Tamansiswa education is Ki Hadjar Dewantara's concept of character education. He wrote an article in *Pusara Magazine* of February 1954 entitled '*Education of character*', noting that was necessary and obligatory for teachers to organize character education for students/learners at schools. "The character education would be better delivered spontaneously by all tutors; it should be delivered any time the opportunities emerged and did not necessarily follow list of lessons. It should be delivered by each tutor while he or she was teaching language, history, culture or natural science, exact science, drawing, and so on" (Dewantara 2004, 2013a, b, 2015; Agus 2017). Elaborating his concept, KHD offered for levels in organizing the character education for students/learners at schools, which were *syariat* (syariat), *hakikat* (essence), *tarikat* (tarikat), and *makrifat* (makrifat) (Dewantara 2004, 2013a, b, 2015; Agus 2017).

a. *Syariat*: It was intended for kindergarten students. The basic character education was delivered by habituating good conducts and putting the emphasis on personal responsibility for following ethics, norms, and general social rules such as kissing hands of elder people, especially parents, paying homage to teachers, greeting friends, taking care and cleaning own equipments and environment, etc.
b. *Hakikat*/essence: It was intended for elementary school students. In this period of education students were habituated doing good conducts following the existing social norms and rules, but at the same time they were taught simple knowledge of each of the lessons they have already got. Thus, they did not have to learn too much lessons and to complete too much assignments, but they have to grasp and digest the meanings of the lessons they got in real life.
c. *Tarikat*: It was intended for junior high school students. It was delivered by habituating good conducts following the existing social norms and rules, while they were given the meaning and the importance of the good conducts through various kinds of school activities in schooling situation and condition. For example sport, poetry, and dance.
d. *Makrifat*: It was intended for senior high school or vocational school students. In this education period the students were given a good understanding and awareness so that the habituated good conducts did not merely become empty habits, but they did all of the good conducts wholeheartedly. In other words, the students did all of the habituated good conducts based on their own understanding and awareness. According to KHD, this might be achieved by doing "*Tri-nga*" (*ngerti* = to understand, *ngrasa* = to feel, *nglakoni* = to act) (Agus 2017).

The character education in Indonesia is intended for all of the people of Indonesia. It was delivered in order to build Indonesian good characters. The national character education is deliberate and well-planed effort to build national characters through education (Agus 2017). It is not merely a schooling process, but a movement in which schooling becomes an integral part of the national character education.

The character education plays an important role in improving the full-human quality of Indonesian people. It was highly required at schools though its basis is family environment supported by social environment. In addition to parents, teachers also play an important role in building character at schools. Therefore, it must start from the teachers. They must be able to prepare themselves to be the ones with good personality and character because the objective of the character education is to prepare Indonesian to be the citizens who loved their country, are intelligent and of noble character with broad national insight and of Indonesian personality. They are responsible for preparing young generation with good character, morality and culture (Agus 2017).

National character building represents culture building process and it involves various parties through education and learning process (Agus 2017). Being people and nation oriented, Swasono (2016a, b) and Swasono and Macaryus (2012) explicitly suggest the followings: (i) Education functions to build and to emphasize self identity, dignity and self confidence; (ii) The education builds the characters of honest, brave, and discipline, (iii) It strengthens faith, (iv) It puts the emphasis on mutual respects, good manners (*unggah-ungguh*), and good conducts, (v) It teaches and gives model of unity and harmonious life and tolerance, respects and values differences, (vi) It teaches and gives model of friendship, hospitality, friendliness, and mutual respect, (vii) It teaches how to be patient and to control emotion; (viii) It stimulates sensitivity, esthetics and arts in order to improve critical, appreciative and creative thinking; (ix) It builds tough character as a nation of dignity, Indonesian identity (*Gestalt*), invulnerable and powerful in nation and character building; (x) It strengthens the sense of nationality or nationalism, the character of loving home country, and also the sense of unity among people (throne for people), (xi) It establishes geographical (territorial) awareness in order to understand self-existence/ground zero and also survival awareness in order to establish national identity, (xii) It establishes "national intelligent life" (cultural concept) and not only improve the intelligence of "the brain of the nation" (biogenetical concept), eliminates condescending sense, servility, and inferiority and underdog mentality (*minderwaardig*), (xiii) It improves national capability to proactively design world future, (xiv) It boosts "modernization" process that is not identical with "westernization", but on the contrary, the modernization that puts the emphasis on Indonesian identity, (xv) It cultivates the values contained in the Five Principles of the Republic of Indonesia, *Pancasila.*

8 Tutoring System

Tutoring system (*among*) is the one with familial spirit and based on nature and independence (Dewantara 2004, 2013a, b, 2015). It also refers to as *Tutwuri Handayani* system. Actually, it is the fundament of national education system as implemented by the Ministry of Education and Culture of the Republic of Indonesia since September 6th, 1977. The *Tutwuri Handayani* means that a leader must support his or her followers when he or she is behind the followers and provides them with independence. The term *Handayani* is defined as exerting empowering influence and if it is necessary in coercive way. It is especially the case when the independence is misused and causes danger for themselves and others.

What has been practiced in schools is Indonesian students are driven to cognitive aspects which emphasize on memory, imitation and repetitive practice (Yulia 2014). Cortazzi and Jin (1996) contend it was due to learning culture of a particular country, while White (1997) added that social studies in Indonesia focusing on content in which lecturing and minimal discussion commonly practiced.

Leaders, including teachers are tutors and responsible for delivering tutoring services ("*ngemong*") and providing independence based on students' ability, but they have to take necessary action if the independence is misused and causes danger for them and others. The tutoring system considers the students as subjects and also as object at the same time in education system. Learners as central figures are given independence to develop and to grow. The interaction between the teachers and the students is dialogical in nature. Students are active and creative in teaching-learning process. The teachers not only deliver teaching and educating services, but also improve students' ability to find necessary knowledge. They only give guidance and if the students do something dangerous they have to give them warning (*Tutwuri Handayani*), while continuously motivate their students (*Ing Madya Mangun Karsa*), and constantly provide their students with models in behavior and speech (*Ing Ngarsa Sung Tulada*). The core of the tutoring system is student-centered learning (Agus 2017).

Our national education is nowadays experiencing backwardness in terms of its quality and the direction of its development as compared to the national education of other countries. The direction of our national education does not have any clear direction in facing global changes. Morally, the education failed to prepare generation responsible for national advancement because they are not able to compete with other nations on this globe (Subagya 2016).

9 Three Education Centers

According to Ki Hadjar Dewantara, education is a cultural and civilized effort to advance human life and to improve human dignity. Schools play an important role in cultivating cultural values. The objective of Tamansiswa is to prepare students to be God believing and fearing human who are physically and psychologically independent, having noble, intelligent reason, skillful, and physically and psychologically healthy in order to be independent member of society responsible for national prosperity, home country and human race in general. In the effort to achieve the objective of the education, Tamansiswa establishes a harmonious cooperation among three centers of education as outlined by KHD, including: family environment, schools, and social environment. There must be a good coordination among the three education centers so that they can help each other in overcoming their respective disadvantages. Also, they have to establish synergetic cooperation in planning and actuating and also instituting education (Dewantara 2004, 2013a, b, 2015; Agus 2017).

During its development, the education tends to sterilize itself from culture. When the education is lack of culture, teaching becomes very dominant. If the education is dominated by teaching, intellectualism becomes unavoidable. Consequently, the knowledge that students get is limited only to knowing and memorizing and not actualized. Recently, it is admitted that many advancements have been achieved. Various regional and international achievements have been achieved by Indonesian students.

However, concerning with the objective of the education, which is to improve human dignity, we still have to work hard to achieve it (Agus 2017).

The direction of our education is considered to be paternalistic in its paradigm because it gives very big portion of knowledge transformation, but it ignores and even set aside the development of attitude, values and good behavior of learners. National education is more likely to ignore affective domain and it has negative impact on students both individually and collectively. Consequently, students will be very knowledgeable of something, but they do not have any value system, good attitude, and positive appreciation and interest in what they know. They will experience imbalance of intellectual development and personal maturity so that they became specialized human and are lack of concern with surrounding environment and highly susceptible to value distortion. Consequently, it is easier for them to fall into moral abuse because they do not have any standard values system to govern their daily behavior (Agus 2017).

It is necessary for us to re-consider KHD's instruction of good character, which is the integrity of human psyche or referred to as good character. Those with good reasoning will always make rational and emotional consideration and use certain standard and other established foundation and it is what makes significant difference between an individual and others (Agus 2017). Furthermore, he suggested that guidance was important considering that children who grew and developed without any guidance would results in bad things in the children. Therefore, it is necessary to establish good foundations for the children, while eliminating the bad ones. Each child must be guided in achieving high intellectuality and also good character.

10 Excellent School for Golden Generation

The government is currently developing the "*Nawacita*" program in the education sector through Mental Revolution. It certainly requires a number of physical development to ensure that education as a part of public service that can be widespread and without discrimination. The role of *Nawacita* as a "road map of the Mental Revolution" is spelled out through the top 10 education priorities. The rearrangement of the national education curriculum by prioritizing the aspect of civic education, which puts proportional aspects of education, such as: the teaching of the history, patriotism values and love of the homeland, the martial spirit of the State and the manners with the development of science and technology. The cost of education is affordable for all citizens. There is no model of uniformity in the national education system—including the national final examination (Agus 2016a, b, 2017).

Development of excellent school for the golden generation must have excellent grades and become a cultural based school, national school, natural environmental school, religious school, local wisdom school, scientific school. This school is an arena of character education for future leaders based on the sense of love and care so that it has the concept, thought and action that should be honest, intelligent, broad, deep and futuristic contributing significantly to the development of the nation. Golden generation has the competence, character, lifestyle, religious values, cultural values, fighting power, attitude, mindset, concept, civilization and insight, superior, intelligent, deep, productive, creative, innovative, and futuristic, to foster real responsibility and contribution in realizing a healthy, peaceful, happy, dignified and sustainable environment (Agus 2016a, b, 2017).

11 The Revitalization of Tamansiswa

Tamansiswa should be able to formulate a new Tamansiswa revival at their 100 years anniversary in 2022. Furthermore, they should contribute golden generation during the celebration of the 100 years anniversary of Indonesian independence. The revitalization of Tamansiswa is so absolute that are believed to be the best therapy for character education of the Indonesian nation can be realized. KHD teachings must be proven internally in the Tamansiswa environment first, in order to be able to be the pride, example, reference and agent of change to improve the quality of superior education for all parties. Tutorial system *among*, *momong and ngemong* not only is spelled out, but should be implemented to improve our nation education system (Agus 2016a, b, 2017, 2018).

Renainsans of Tamansiswa dan Jogja city begins with revitalizing its mandate, vision, mission and objectives to effectively play an active role in the development of national education system based on culture and humanity (Agus 2017, 2018). The determination of the main strategic issue correctly and accurately determines their existence, condition and performance. The next stage should be self-evaluation in an objective, rational, deep, structured integrated and comprehensive, involving all parties. The expressions of self-evaluation analysis should include their internal environmental factors including cultural organization. External environmental factors (local, national, regional, international global) should also be conducted in-depth analysis, covering trends (ideology, politics, culture, science, education system and soon), stakeholders (government, students and students, industry, society, government, businessmen etc.). Identification of the major problems that are acute and chronic must be able to be detected and formulated clearly. Thus, it can be found an alternative solution to treat diseases over the years.

Factors supporting the success of the renewal program of Tamansiswa and Jogja require an active and tangible contribution from all stakeholders. Therefore, it is necessary for executor, program, management, financial and performance indicators to encourage all stakeholders to have a track record, ability, willingness, opportunity, authority, credibility, trust to support success and mutual prosperity.

The KHD implementation in Tamansiswa and Jogja requires vertical and horizontal relation and takes into account local wisdom as well. Great concept should be ready; it must be program orientation, not project oriented, same perception, empowerment of all stakeholders, as needed, beneficial principles, from upstream to downstream, with performance indicators, internal and external monitoring, following up and program sustainability (Agus 2017, 2018). The key indicator of success is not the completion of financial administration accountability and conformity with standard operational procedure.

It needs a total revolution to realize the privileges of Golden Indonesia through a performance-based, integrated, comprehensive, non-egocentric program, and real benefit in the form of common welfare, on economic, environmental and socio-cultural aspects (Agus 2017). The key indicator of success is not performed both administratively and financially. It requires strong policy, strategic, leadership, regulation, implementation, commitment, and participation to create management of natural resources and people supporting system and education practice completely (Agus 2018).

12 Conclusion

KHD's noble teachings has their root deep in the noble culture of Indonesia that contributing to the advancement in education and development Education is not only the matter of brain intelligence, but also good character building that must be organized by adopting the cultural concept of "Three Excellent Soul" consisting of create, feel and intend that respectively means reason, emotion and intention. The synergetic combination of the three psychological powers may result in quality reasoning, fine emotional aspect, and strong motivation. KHD applied Three Education Centers, including family, school and society for formal education, informal education and non-formal education in synergetic and balanced way that does not put the responsibility for education merely on the school. It is necessary to apply the tutoring system in teaching and education process that are based on sharpen, love and nurture. The concept of "Trilogy of leadership" in front to be the model, in the middle to raise the spirit, behind to encourage, has been the most important reference for Indonesian people, although the concept has not been well-implemented. Total restoration of the national education system of the Republic of Indonesia must be organized in smart, large scale, in-depth, creative, innovative, integrated, comprehensive and futuristic way, but must be firmly rooted in the noble culture of Indonesia. Therefore, it will be the front line in the National Resurrection II in the coming commemoration of 100 years of Indonesian Independence in 2045.

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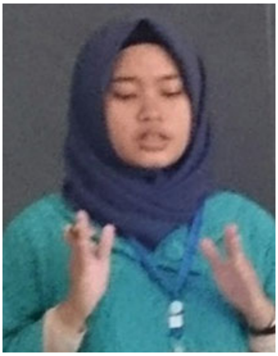

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Academic Strengthening Through a Multi-disciplinary Ph.D. in Sustainable Development

Wasan Kanchanamukda and Lindsay Falvey

Abstract Sustainable development is being integrated into higher education through diverse mechanisms. This paper describes a process that combines both the introduction of sustainable development and its use for a change process in an evolving environment. Thaksin University, located in the south of Thailand near the Malaysian border, is continuing its academic development through an international standard research-based Ph.D. program that spans all disciplines in the university. Beginning with the objective of strengthening the academy in an environment where Ph.D. programs are usually coursework-based and conducted in the Thai language, a strategic plan was developed to include engaging staff of international universities to assist in supervision and examination of research theses prepared in English. Research topics include sustainability within the subject and discipline being researched and so assist discussion within the wider university through candidate seminars and publications. Through this process, the university seeks to further embed sustainability principles in its other courses while further strengthening its regional image. In combination with other field-based activities, the approach has borne fruit in the form of commendations from national reviews and in university rankings. The paper describes the process of establishment of the university-wide Ph.D. in Sustainable Development in a manner that may be of value to other institutions with autonomous governance.

Keywords Education · Sustainable development · Doctoral · Thailand · ASEAN

1 Introduction

Universities have a prime responsibility to orient their knowledge and its imparting to sustainability. In doing so, the objective nature of university research and teaching requires that approaches to sustainability be realistic, cutting through some of the

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idealism that can otherwise pervade notions of sustainability. Furthermore, understanding of sustainability must be encompassing in order to acknowledge the myriad interrelationships between all things, including thought. One of the significant advances in harmonizing understanding around sustainable development is represented by the Sustainable Development Goals of the United Nations (SDGs). While these have been criticized on various bases, they are perhaps the broadest general consensus on global needs. The presentation of the SDGs as being interrelated and applicable to all nations, not just so-called developing nations, represents a major advance of relevance to the subject of this paper.

The paper describes the process of establishment of the university-wide Ph.D. in Sustainable Development in a manner that may be of value to other institutions with autonomous governance.

2 Integrating Sustainability into University Education

In a wealthy nation, university education may overtly aim to influence individuals and society so that they are cognizant of the interactions of their lifestyles and employment with all beings and the so-called inanimate components of our environment (Hegarty et al. 2011). Universities accept this responsibility to varying extents, some focusing on the physical sustainability of their campuses, others on the sustainability of their business models. However, a more important approach is the integration of sustainability into the research and teaching programs of an institution (Leal Filho 2010). While descriptions of 'green curricula' is a start of the process (Haigh 2010), a liberal arts approach that ensures all undergraduates gain a foundation in the integration of the humanities and the sciences offers potential that may not be as present in vocationally oriented degree programs. This was, for example, a basis of the 'Melbourne Model' introduced in the University of Melbourne in Australia, an approach that may be more difficult to implement in universities without large discretionary funds (Davies and Devlin 2007).

In addition to the constraints of state-controlled curricula or funding by student load to adopting an integrated foundation degree course across all disciplines, objectives that focus on western-lifestyles that are said to be ecologically sustainable (Sterling 2001) can often ignore the global context. That global context includes the overwhelming issues of poor and food-insecure nations where sustainability trade-offs more than offset noble actions in wealthy nations. It also excludes the constraints on many universities in emerging and aid-graduating nations.

Systems-thinking has long been a means of introducing students to the complexity of the biological environment. In the applied biological sciences such as medical and agricultural sciences it has introduced social, environmental and biochemical interactions into the thinking of capable students. Predating widespread use of 'sustainability', such a systems-thinking approach has nevertheless equipped many graduates with an integrated approach to understanding the context of their professional and private actions. This observation may suggest that self-contained courses offering an integrated approach might meet the criteria of sustainability and sustainable development. However, in terms of university impact, such courses are ipso facto marginalized if the bulk of an institution's offerings remain un-integrated. This seems to have been the fate of some environmental science and environmental studies courses, although it has been argued that such courses can be an initial means of raising awareness in an institution in a step-wise process to spread the concept of sustainability across all courses (Liu 2011). An alternative to beginning with undergraduate courses is to start a new graduate program that spans all disciplines, as commenced at Thaksin University in 2010.

3 Thaksin University Ph.D. Program

Thaksin University is a Royal Thai Government public university, and one of the few granted a measure of autonomy. Located in Songkhla and Phattalung provinces in the south of Thailand, Thaksin University spans major disciplines with a rising cadre of internationally qualified faculty. It also maintains the Southern Thai Studies Centre and Museum complex on Ko Yo island in the extensive Songkhla Lakes System as a research and study facility, and various other research and development sites.

Transitioning from a fully government-controlled university to what is termed autonomous in the Thai system, Thaksin University determined to judiciously use its resources in a manner different from when it was more constrained by government (Kanchanamukda 2014). One of these different approaches was a programmatic approach to spread the concept of sustainability and sustainable development across the university's offerings by creating a new doctoral program. This differs from the popular norm in Thailand (Hallinger 2011); first because the Ph.D. program was to be research-based, and second because it was to be truly international by involving academics from leading foreign universities. Most doctorates in Thailand are coursework-based and in some cases, despite some being labelled 'international', they can quickly become dominated by Thai language when it is a mode of communication between Thai students.

The vision of the program was simply to create a learning organization that conducts research training relevant to the ASEAN region at an international level, and in so doing provide a means of lifting other academic programs of the university. Making it applicable to all departments in the university required a unifying theme—hence the program's focus on sustainable development. The geographical focus of the ASEAN region and beyond reflects the central location of Thaksin University in what was part of ancient Sri Wijaya trading kingdom and consequent historic links to modern neighbouring nations (Hall 1992), as indicated in Fig. 1.

In continuing its academic development through an international-standard research-based Ph.D. program that spans all disciplines, the university engages international universities' staff to assist in supervision and examination of research theses prepared in the English language. Research topics include sustainability within the subject and discipline being researched, which assists discussion within the wider

Fig. 1 Location of Thaksin University (adapted from Googlemaps)

university through candidate seminars and publications. Through this process, the university seeks to further embed sustainability principles in its other courses while continuing to strengthen its regional image. In combination with other field-based activities, the approach has borne fruit in the form of commendations from national reviews, university rankings and awards.

4 The Program

Without indulging in the endless descriptions of sustainability and sustainable development, it is sufficient here to define the Thaksin University approach as being within Sach's description, which was the basis for the formulation of the UN Sustainable Development Goals (United Nations 2016). He defined '*sustainable development* [as] *the holistic integration of economic, social, and environmental objectives in an approach to scientific analysis, governance, problem solving, and human action*' (Sachs 2015). The SDGs themselves, while criticized, can be seen as an advance in global cooperation insofar as they apply to all nations—not only to developing nations—and to all sectors and disciplines. Understanding the integrated nature of all things is the key to sustainable development. This is apposite in the Southeast Asian region where historically commerce underwrote sustainable development for centuries before the colonial period through such integration of governance and problem solving to regional benefit (Falvey 2016).

This thesis-based Ph.D. program follows international practice in Australia, Britain and Canada. Thus it differs from many programs of universities in Thailand that are often based on coursework. In abiding by international standards, the resultant thesis exhibits its author's understanding of the context of the work, its contribution to world knowledge and its cohesion as a sustained logical exposition (Thaksin University 2017). As such it offers wide international credibility, especially in the ASEAN Region. The program is considered most appropriate for future academic development as ASEAN's university sector becomes more international and cohesive in character (Wongsothorn 1997).

Covering all disciplines common to comprehensive universities, the program follows the approach of Thaksin University's motto that "morality and wisdom precede development", which translates directly in a sustainable development approach that applies to fine arts as much as to technology, and as a consequence contributes to the integrity of the region. Disciplines covered to date include: Social and Community Development, Agriculture Science and Management, Natural Resource Management, Education Development, Art and Culture, Environment Science, and Business Management among others (Thaksin University 2017).

The program's academic governance is conducted by a committee that meets quarterly and includes two University Vice Presidents (Academic and Finance), experience graduate supervisors from the university and three senior international academics from Australia and Canada.

To enter the program, candidates must have appropriate degrees or demonstrate high-level equivalence from professional experience. Preparatory coursework is assigned as required in such fields as research skills, reference library use, ethics, plagiarism, intellectual property and writing. As the program adopts English as its international language, all candidates whose prior qualifications were not undertaken in English in an English-speaking environment are considered on the basis of tests including IELTS and TOEFL, supplemented by interviews with native English-speaking academics of the program. Credit transfers are allowed subject to entrance requirements of the fee-based program. In addition to general university and government requirements, all candidates must agree that they will publish, as relevant, in appropriate journals and in selected cases as a specially edited book through Thaksin University Press. To date six books from the Ph.D. program have been published five of which result from theses and one that presents a unifying context for the program's study of the region (Fig. 2). Print versions of the books are sold through the publisher and have also been made available online for free download. Scholarships are offered for ASEAN candidates on a competitive basis to further spread the concept of sustainable development being a border-transcending concept.

Fig. 2 Books adapted from five completed theses, and one contextualizing the region

5 Spanning Disciplines

As international research degrees are based on the creation of knowledge, and the means of communicating knowledge varies between disciplines, the program accommodates different modes of presentation. In scientific and technical fields, the commonly accepted form of a prolonged period of investigation collated into a prescribed format of thesis is used. In some cases where candidates publish in recognized high quality international journals, papers may form the basis of a thesis that provides an overall global context of the work. In other disciplines such as the performance and visual arts, other forms are able to be considered, such as performance or exhibition supported by an exegesis. While topics cover all disciplines, some are constrained by the availability of qualified international supervisors.

Fig. 3 Alignment of the Program to the United Nations Sustainable Development Goals (United Nations 2016)

Since its commencement in 2010, the program has enrolled 15 candidates and graduated 9. Research topics covered to date include:

- Recovery responses to cyclone devastation in Myanmar
- Improved leather processing technologies in Thailand
- Financial management in autonomous Thai universities
- Ethnic distinctions and citizenship in Myanmar
- Environmental impacts of mangrove destruction in Thailand
- Management and governance of irrigation in Laos
- Comparisons of Islamic and government schools in Southern Thailand
- Curriculum reform on Chinese secondary teaching in Thailand
- Developing a high resolution wind atlas for Thailand
- Sustainable food and industrial energy production from palm oil
- Comparison of business attitudes in Cambodia, Malaysia, Myanmar and Thailand
- Innovation of human resource practices in the manufacturing sector in Thailand
- The effect of rice policies and marketing on farm income for specific rice varieties
- Sustainable development in the Thailand-Singapore railway project
- Assessing wind resources using coupled atmospheric and wind flow modelling.

From these examples, it can be seen that experience to date has spanned most of the Sustainable Development Goals (SDGs). Figure 3 is an aspirational presentation in which the ticks (✓) indicate the intent of the Ph.D. program in Sustainable Development. It is more appropriate to understand the approach as orienting each disciple to the SDGs than designing specific sustainable development studies separate from disciplinary studies.

6 Conclusion

In seeking to spread sustainable development through the university, a number of initiatives have emerged from the program. Apart from the theses, books, seminars and demonstrations within the university, a further example of the impact of the program is the joint management of the international conference of the AFBE—the Asian Forum of Business Education. The conference was held recently in Phuket on the theme of "Creativity and Innovation for Smart Societies and Sustainable Development". The conference was managed through the university's International College, which was established for the all international programs of which the international Ph.D. program is the major activity at present. Including sustainable development as the theme for business educators is seen as an output of this program of academic strengthening through an emphasis sustainable development.

The program outlined in this paper is a modest example of a viable means of integrating sustainable development into a university that builds on an intention to strengthen the academy by use of a multi-disciplinary international Ph.D. in sustainable development.

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Integrating Sustainability within University Sustainability Programme—Students' Perception on Sustainable Cities and Communities Master's Programme of the School of Humanities, USM

Hafizah Rosli, Narimah Samat and Radieah Mohd. Nor

Abstract The sustainability pillars seemed to have been embedded into most of higher educational institutions, throughout the world. Universiti Sains Malaysia as an APEX university has integrated Education for Sustainable Development (ESD) to ensure its community lives in accordance with the sustainability objectives. To achieve this, Sustainable Cities and Communities Master Programme is an impressive effort to educate future leaders about the vitality of sustainability in developing a city and its community. In this paper, seven graduate students from this master programme were interviewed regarding their perceptions about the ESD that they have learned from the programme. One of the students admitted that this programme is a good platform to understand about urban social issues and problems in relation with the sustainable development, poverty, community's response on infrastructure development and so on. In his opinion, the understanding about sustainability from the programme is beneficial.

Keywords Education for Sustainable Development (ESD) · Perceptions about ESD · Sustainable development and sustainable cities and communities

1 Introduction

Sustainable development is a strategic idea which ensures all social needs, are in equilibrium with economic growth and environmental integrity. Integrating sustainable development into the educational system will help nurture future generations and provide them with the need to embrace ecological protection, conservation of resources and human development (Abdul Razak et al. 2008). However, to ensure

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these ideas become a reality, rather than just rhetoric, the system of our society needs to face a huge challenge to deliver the idea of sustainable development for a more sustainable future (Abdul Razak et al. 2008). Kofi Annan, the former UN Secretary General, (as cited in Abdul Razak et al. (2008), has voiced his views, "Our biggest challenge in this new century is to take an idea that sounds abstract—sustainable development—and turn it into reality for the world's people". Hence, educating people on sustainability is not something impossible but to ensure that they put the knowledge to practice is not an easy task to implement. In addition, as sustainability idea seems to be vital, it should be embedded into the higher education programmes for nurturing the sustainability practices right from the roots (Hussin and Kunjuraman 2015). Education for sustainable development (ESD) is the major means to ensure the human behaviour and practices parallel the healthy and sustainable life (Yasin and Rahman 2011).

This paper is based on research to gauge students' perceptions on sustainable studies programme offered by a university. This paper will discuss how Universiti Sains Malaysia, Penang, Malaysia adopts the four keys actions framework from its Blue Ocean Strategy, to integrate sustainability elements into its teaching and learning activities. This paper will also focus on Sustainable Cities and Communities Master Programme (MSc SCC) which has been offered at postgraduate level, as an extension of the adoption. Hence, this research aims to obtain the students' perceptions on MSc SCC programme, offered at the School of Humanities, USM, and its effectiveness in conveying and educating the idea of sustainable development, and ensuring the delivery goals are met. This research was conducted using qualitative research method, by conducting in-depth interviews with seven of graduate students from the Sustainable Cities and Communities Master Programme offered at Universiti Sains Malaysia, Penang, Malaysia. From the analysis of the data, the study found that this MSc SCC programme is a good platform in disseminating sustainable development. However, it needs more effective strategies if this programme were to be a catalyst in changing individual's lifestyle towards sustainability.

2 Integrating Sustainable Development into University Programmes

Higher education is the core dynamics of the development of skilled and knowledgeable human resources. Providing the skill practices, consultancies, trainings, and knowledge exchange, higher education can contribute unique intellectual sources for building a sustainable society (Shi and Lai 2013). For that reason, the Organization for Economic Cooperation and Development (OECD) suggested that higher education institutions should be the key players for generating human capital in areas of sustainability; higher education institutions need to play role as the sources of expertise in sustainability through research, consultancy and demonstration. They can play a brokerage role in bringing together diverse regional actors and elements of capacity to the sustainability process. They can promote sustainability good practices in on-campus management and development activities, strategic planning, building design, waste minimization and water and energy consumption efficiency, pursuing good citizen type as well as giving recognition and reward to members of the staff and students who participate and are committed to sustainability practices in campus (OECD 2007).

The interdependence between human and the environment, and the role of higher education in achieving sustainability have been addressed in The Stockholm Declaration, 1972. The declaration focused on the relation of the sources of higher education such as their leaders, lecturers, researchers and students with the functions of responding to all challenges in balancing the human quest for economic and technological development, with the environmental preservation (Shi and Lai 2013). The Stockholm Conference on the Human Environment in 1972 has sparked international interest in fostering the most important role in promoting sustainability through higher education (Calder and Clugston 2003). Among them, Agenda 21 and a series of HESD declarations and conferences in the 1990s have been shaped and have integrated sustainability appropriately with higher education level (Calder and Clugston 2003). The UN Decade of Education for Sustainable Development (2005–2014) has been specially designed purposely to mobilise sustainability into the educational resources of the world (Newman 2014).

Sherry (2003, as cited in Lozano 2006) has specified that elements of initiation, implementation and institutionalisation as three stages of "innovation adoption" of sustainability in higher education institutions. Winter and Cotton (2012) highlighted that to adopt ESD in higher education institutions, not only that the teaching and learning aspects have to be taken into consideration, but also the extra-curricular activities, the so-called "hidden curriculum" have to be considered. Integrating ESD into higher education institutions are the results of global developments such as the DESD, SDGs, and so on (Kapitulcinova et al. 2018). Effectively, this effort works in two ways; shaping the universities and being shaped by the universities (Kapitulcinova et al. 2018). This integration involves different levels and various pathways, such as via national or international channels, including individuals (faculty, researchers, or students).

Figure 1 shows that there are three stages of sustainability maturation process or innovation adoption curve (Kapitulcinova et al. 2018; Lozano 2006; Newman 2007; Rogers 2003; Sherry 2003), and the "sustainable university" concept (Lukman and Glavic 2007; Velazquez et al. 2006). The figure shows that a "sustainable university" begins its sustainability journey from its "business-as-usual university" as the starting point (Kapitulcinova et al. 2018). Afterwards, as the degree of integration keeps on rising, the integration stages start to reach the awakening stage, then, pioneering and transformation stages respectively until it reaches the aspirational state where it becomes a "sustainable university."

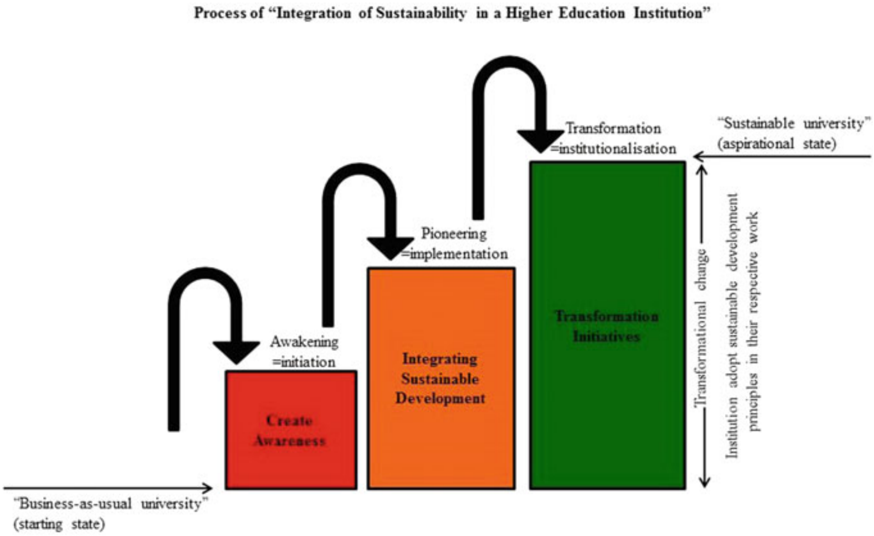

Fig. 1 Taken and adapted from Conceptual Model for defining the term "Sustainability Integration in Higher Education" and "Transformational Change" from a Whole-Institution perspective at HEIs (Kapitulcinova et al. 2018)

2.1 *Strategies of Disseminating ESD in Higher Education Institutions*

Learning requires an equitability of mind, body and soul as well as the inner and the outer experiences (Stavinshi and Muresan 2018). Learning is generating knowledge as its product, which may comprise an ensemble, unity of information, competencies and values. The integration of learning and knowledge consists of a superior understanding of their meaning. The traditional education will involve the proper social insertion of the individual, while the transdisciplinary education as an integrated knowledge, which seeks for the understanding of the meaning of the knowledge (Stavinshi and Muresan 2018). Therefore, the teaching and learning process will possibly enable the acquiring of transdisciplinary knowledge and understanding it effectively.

Apparently, as higher education institutions are one of the sources of ESD, it is necessary to incorporate the concepts of sustainability into professional practice including all engineering and science programmes to increase the level of awareness of sustainability among the society (Du et al. 2013). In that case, to disseminate ESD into a transdisciplinary field, suitable learning models of the rapid changes of the knowledge society need to be used as a guideline.

The Four Pillars of Education (adapted into Fig. 2), may be the right choice, as it is comprehensive in giving the knowledge until the good practices become a healthy and sustainable lifestyle. This model will facilitate the understanding of

Fig. 2 Taken and adapted from *The four pillars of education from traditional and transdisciplinary perspecti*ve (Stavinshi and Muresan 2018)

lecturers and students about their roles in their university as a higher education institution. Four main elements in The Four Pillars of Education are learning to know, learning to do, learning to be and learning to live together (UNESCO 2017). First, "learning to know" will enable students to acquire the cognitive tools which require them to better comprehend the world and its complexities by developing concentration, memory skills and ability to think. Then, "learning to do" enables the skills such as personal competence, which combines the skills, talent, certified skills through technical and vocational training, social behaviour, interpersonal (social and communication) skills personal initiative and willingness to take risks, that will allocate individuals to participate in the global economy and global society (Abdul Razak et al. 2008). Meanwhile, "learning to be" is helping individuals to obtain self-analytical and social skills to the fullest potential, to help them develop affectively and physically, to be the all-round complete person (UNESCO 2017). Hence, they will be able develop an independent, critical thinking and strategic judgement, so that, they will make the right decision on the best courses of action in the respective different circumstances they face. Finally, "learning to live together" is the exposure to the implicit values pertaining to humanity, such as democratic, cultural, respect, and peace. This exposure will encourage individuals to live in peaceful and harmonic situation, even though they cannot avoid the differences and conflicts among them (UNESCO 2017).

On the other hand, the Blue Ocean Strategy is an appropriate strategy to be adopted for disseminating sustainability through the strategies of higher education institutions. In the blue ocean strategy, the four-action framework consisting mainly of four elements, namely eliminate, reduce, raise and create was purposely developed by W. Chan Kim and Renée Mauborgne to guide strategic decision making by considering elements of buyer value in crafting a new value curve or strategic profile (Kim and

Table 1 Eliminate-Reduce-Raise-Create Grid (ERRC) (Abdul Razak et al. 2008)

Eliminate-Reduce-Raise-Create Grid (ERRC)		
Eliminate and/or Reduce	**Raise**	**Create**
1) Examinations 2) Lectures 3) Rote Learning 4) Apathy	1) Student-centered Curricula 2) Market Relevance 3) Alternative Assessments 4) Technology-enhanced Learning (TEL) 5) Nurturing Skills/Competencies 6) Linking Research to Learning 7) Sustainability Development (SD) Curricula	1)Non-traditional Entry 2)Open Course Ware (OCW) 3)Enhanced Open Learning (EOL)

Mauborgne 2005). Universiti Sains Malaysia (USM) is a Malaysian public university committed to mainstream the principles of sustainability in most of its core areas that include skills, thinking, research, community engagement and best practices in striving and sustaining the university as sustainability-led university in Malaysia (CGSS 2018). Hence, USM has intensified itself in implementing projects in line with sustainable transformational logic and practice as its core activities (Campbell 2015).

In its transformation towards sustainable development, USM refers to the Blue Ocean Strategy for integrating the concept of sustainability into its higher education. This was implemented by adopting its four key actions framework, that is, eliminate and reduce, raise and create in most of their teaching and learning aspects. Then, these four key actions framework was structured into the eliminate-reduce-raise-create grid (ERRC) as shown in Table 1, which evolved from its strategies for nurturing and learning (commonly referred to as teaching and learning).

Figure 3 shows the Eliminate-Reduce-Raise-Create grid (ERRC). In this scheme, examinations, lectures, rote learning and apathy were listed as things to be eliminated and to be reduced. First, examinations need to be eliminated as it will only drive students to use their knowledge to target for obtaining the best grade in those examinations. Besides, most lectures conduct their lectures as monologues in front of very impersonal big classes with the assumption that every student has the same level of skills, knowledge, understanding and interest (one-size-fits-all) (Abdul Razak et al. 2008). Meanwhile, the rote learning will become an obstacle for students to apply their knowledge obtained in their real life, as the knowledge transferred only encourages them to do memory work rather than to encourage to be creative and innovative. Lastly, apathy indicates that students' level of social conscience is low as they are not interested to make changes in their daily practices sustainably.

The second grid of ERRC, "raise" means to introduce student-centred curricula, market relevance, alternative assessments, technology-enhanced learning (TEL), nurturing skills or competencies, linking research to learning, and sustainability development (SD) curricula (Abdul Razak et al. 2008). Student-centred curricula refers to diverse educational programmes, learning experiences, instructional approaches, and academic-support strategies, which are intended to address the distinct learning needs, interests, aspirations, or cultural backgrounds of individuals who need a variety of educational methods with different learning styles, abilities (physical and non-physical), types of activities, the students' level of understanding or knowledge, multiple intelligences, and even divergent academic and non-academic interests of the students (Abdul Razak et al. 2008; Student-Centered Learning 2014). The curricula must be flexible, encouraging social learning collaborations and suitable for transdisciplinary approach for disseminating skills and tools, particularly that can change individual's lifestyle towards sustainability such as problem-based learning (PBL) and outcome-based education (OBE). Furthermore, alternative assessments are methods in implementing student-centred curricula using portfolios, rubrics, matrices, peer assessments and personal reflections, which will take into account each student's learning style, multiple intelligence, analytical capabilities and interests. On the other hand, market relevance is vital to prevent students from being jobless. The theories and knowledge they have obtained during their varsity life must be in line with the need and requirements of practical and industry market (Abdul Razak et al. 2008).

E-learning which embraces infostructure, new markets, new applications, open access, social networking and video-conferencing categorised as technology-enhanced learning (TEL) that is getting wider acceptability as it enhances learning experience for the digital natives familiar with podcasting, blogging, massively multiplayer online role-playing games (MMORPG), electronic forums, multitasking, instant gratification, and so on (Higher Education Academy 2015). Then, nurturing skills or competencies are necessarily to be disseminated by capable and acquire all needed skills lecturers to nurture learning and relinquish their role in mentoring and facilitating students.

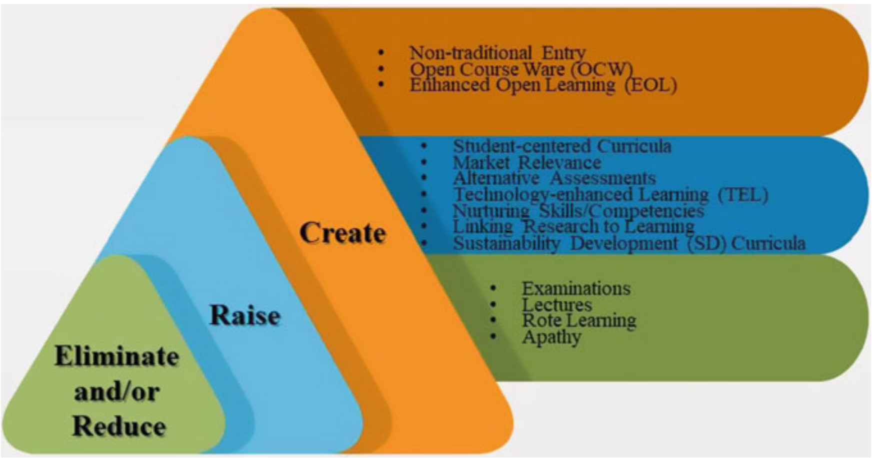

Fig. 3 Taken and adapted from *Eliminate-reduce-raise-create grid* (ERRC) by Razak and Mohamed (2008)

Regarding "linking research to learning," it is one of the "raise" element in ERRC; it is actually, an internationally interesting topic to link research with teaching and learning in different forms (Healey 2005). Moreover, it may be found in all kinds of higher education institutions with different complexities and contested nature of the research-teaching nexus in different national and institutional contexts, with particular reference to geography and different types of challenges (Healey 2005). Nowadays, incorporating sustainable development (SD) curricula in transdisciplinary fields are really needed, especially in the vision of developing a sustainability-led university. For that reason, all the programmes and courses need to be reviewed and revised, to identify the possible areas of sustainability issues that can be integrated into them. That is the reason why sustainable development (SD) curricula are considered as one of the "raise" elements in the ERRC (Abdul Razak et al. 2008).

The first "create" element in EERC is non-traditional entry, which means the accommodation of students with different abilities (physical and non-physical), capabilities, talents, experiences and intelligences who would otherwise not benefit from the democratisation of knowledge (Abdul Razak et al. 2008). Second, open course ware (OCW) is a public free-of-charge courses which have been purposely created for transferring knowledge and education in the university. Finally, enhanced open learning (EOL) is a way of adding value to the university and students by offering certification as an option for OCW students at the completion of the course.

2.2 Approaches in Promoting Sustainable Development Through Higher Education

Sustainability which is closely related to complexity, innovation, and interdisciplinary is increasingly being integrated into the tertiary education curricula at the universities. Hence, to integrate the sustainability into university curricula, alternative approaches, other than traditional lecture-based pedagogy are needed (Du et al. 2013). Yasin and Rahman (2011) proposed a framework of learning to be integrated into institutions of higher learning to promote education for sustainable development. The framework of learning should include lifelong learning, interdisciplinary approaches, systems thinking, partnerships, multicultural perspectives and empowerment (Yasin and Rahman 2011).

On the other hand, based on Lehmann et al. (2008, as cited in Du et al. 2013), previous studies have documented that problem-based and project-based learning (PBL) are innovative pedagogies for education in sustainability. In recent years, higher education institutions are apparently turning away from traditional lecture-based pedagogy approaches to the PBL method. Nevertheless, few studies have been conducted to convince the relationship between PBL in disseminating knowledge on sustainable development (Du et al. 2013). However, it seems that if sustainable development curricula are implemented using the PBL method, students will be more encouraged to practice the good practices of sustainability in their daily life,

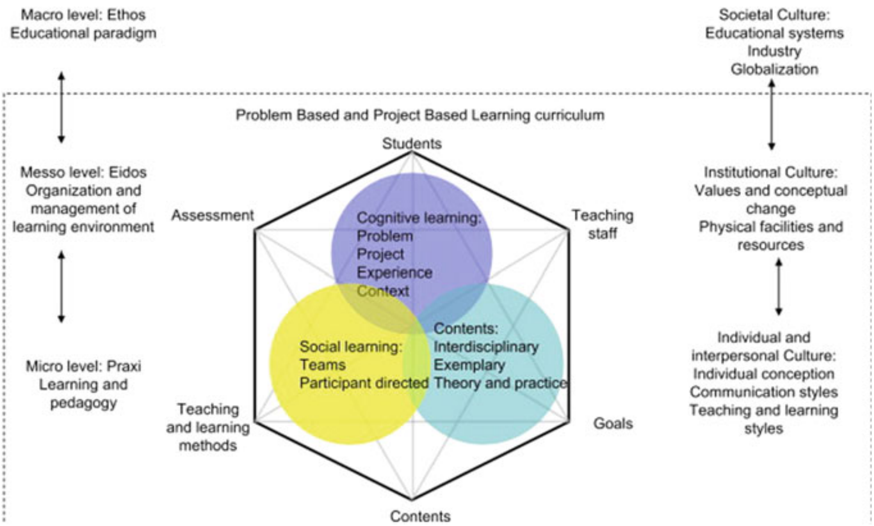

Fig. 4 Change in educational culture for sustainability curricula using PBL methodology. Taken and adapted from Du et al. (2013)

consequently, promoting a sustainable lifestyle among them. This could happen as the PBL method is facilitating participative learning, critical reflection, system thinking, creativity and cultural awareness (Du et al. 2013).

Figure 4 shows the work of Du et al. (2013), a framework of change in educational culture for sustainability when PBL methodology has been used. This framework was constructed with the objective of inspiring curriculum design for sustainability education and analysing the implementation of PBL in a given cultural context. The framework consists of three layers, namely, macro, messo and micro. At the micro setting lie all great influences in the teaching and learning practices including attitudes, styles, communication, and negotiation (Du et al. 2013). At this micro level, the individual's understanding and perception will be reflected through his or her behaviour, interpersonal communications, relationships, and so on. Meanwhile, at the macro level, societal and professional cultures take place, where the historical, religious, economic, and political traditions will be influencing the structure of educational philosophy (Du et al. 2013). Furthermore, the learning environment will be constructed based on the local values, physical facilities and resources, and this part lies at the messo level, where institutional culture with curriculum and the institutional context take place (Du et al. 2013).

2.3 Sustainable Cities and Communities Programme

All aspects of university life including teaching, learning, research, and societal integration are key issues in implementing sustainability studies in the higher education institutions (Du et al. 2013).

Well-educated students with sustainable development is the best outcome from ESD. All of these need the existence of educational offer as well as students; and the core actors in ESD are those students (Holgaard et al. 2016). Nevertheless, to integrate ESD as a transdisciplinary field is quite challenging. Haase (2014, as cited in Holgaard et al. 2016), a Danish nationwide investigation had been conducted to newly enrolled engineering students. The study found that it is challenging to put the sustainability approaches on the agenda among mathematics and science students, as their intrinsic motivation was not closely aligned to other motives in studying engineering.

Leaders in university needs to play their important role in "walking the talk," so that comprehensive strategies of sustainable development, involving environmental management, corporate social responsibility and healthy economy will be implemented (Holgaard et al. 2016). These strategies should include supporting ESD activities, sustainable campus activities as well as ESD development projects and research. Besides, leaders in universities need to ensure that their teaching staff or educators have been sufficiently trained and are ready for the challenges the issue of integration ESD into their academic programmes. This means that they need to be well-prepared to be the gatekeepers for the realisation of ESD and delivering sustainability in an interdisciplinary mode, even though it is some kind of complex and integrative nature of ESD (Holgaard et al. 2016). Norden (2014) in her study found that overall educators who worked in the project with deep-level processing for learning ESD in an integrated manner in the transdisciplinary framework experience tensions between their resources and capabilities, and the challenges they faced in the project. They need to identify two main approaches in teaching sustainability in transdisciplinary mode. First, they have to struggle with the issue of transdisciplinarity. Second, they need to show ownership and capability to reconceptualise the project as a whole (Norden 2014).

2.4 Examples of Sustainable Development Programmes

In Norway, the University of Bergen offers an undergraduate course sustainable development core course, namely, Bachelor of Sustainability, Cities and Communities. This programme was specially designed to provide students with a deep understanding of human geography and the human geographical perspectives on the world using theoretical and methodological insights based on theories and cases from human geographical research (University of Bergen 2015). This sustainability course was offered to emphasise on the urban climate change as well as the energy consumption among urban communities. The course starts with human geographical perspectives on space, space and scale to enable students to be familiar with current processes of change and contestation at different scales and the forces behind the changes in place, related to planning, resources and energy, environment and the climate, economic development, innovation and meaning of production (University of Bergen 2015). Students will also be exposed to contemporary challenges for the development of sustainable cities and communities using examples given during lectures.

In Denmark, Aalborg University, Copenhagen, also offers a master programme which integrates sustainable development education into the programme, known as Master of Science in Sustainable Cities. This programme discusses the challenges and impact of cities as well as businesses with the environment, society and the economy (Aalborg University 2007). Furthermore, this programme trains students to address the modern challenges with all the sustainable development practices (Aalborg University 2007). Topics discussed in this programme are especially significant for the present as the population growth and the development are expected to reach 70–80% of the world population living in cities in the future (Aalborg University 2007). To prepare the students for the future challenges, they need to obtain the appropriate knowledge; they will have to face all the challenges, especially in the planning sectors involving energy, water, waste disposal, urban planning, and so on.

In London, King's College London is also following in line with education of sustainable development for the future challenges. They are offering a master programme, called MSc/MA of Sustainable Cities. The programme offered at King's College London is a programme explicitly unique in the UK. It focuses on discussing topics related to sustainable cities; it is an interdisciplinary course that focuses on the human and physical processes that shape urban ecologies and environments. It offers students the opportunity to gain practical experience through an internship programme (King's College London 2018). The programme aims to develop students' critical understanding of the interrelationships between urbanization and human lifestyles, politics, economy, ecology and environment, human impacts on physical processes in cities, and the implications for habitation and liveability; students can develop their ability to evaluate advanced scholarship in the field of urban policy critically, with reference to sustainable environmental management. It promotes initiative and develops their independent critical judgment to identifying, analysing and solving problems at an advanced level. It also helps them develop their relevant transferable skills, which are embedded in the learning and assessment schemes; develop their practical skills in data handling, interpretation and use, and develop their skills in connecting physical dynamics to social, political and management processes. In addition, it also enables them to focus on the challenges of managing cities in an integrated and sustainable manner, regardless of their first-degree discipline and to enable them to deploy scientific, social and economic theory within a sustainability framework. The course also takes into account the need to address the needs of society, the economy and the protection of environmental services (King's College London 2018).

3 Research Methodology

Nowadays, university sustainability assessment schemes are also becoming more popular as the higher education institutions are playing their important role in fostering sustainable development (Shi and Lai 2013). Higher education institutions are the best platforms to provide education for producing leaders who can lead the community towards sustainability. Even though there are many public and private universities in Malaysia, not all of these universities are integrating sustainable development into their programmes.

The School of Humanities, Universiti Sains Malaysia (USM), offers a sustainability programme at the postgraduate level, particularly related to sustainability in cities and their communities. This programme was offered to produce graduates who can appreciate and apply the integration of art-science (fusion) scientific knowledge to address issues of management and governance of cities and sustainable communities in the context of sustainable development and management (Universiti Sains Malaysia 2012). The course also focuses on the intricate relationship between human and physical processes that shape the ecology and urban environment. This programme explores the social and ecological processes in a city that has a complexity, a conflict and a diversity of its own (Universiti Sains Malaysia 2012). The programme structure is flexible to allow students the opportunities of enhancing certain field of studies by doing research topics based on their interest, ability and educational experience. This programme is offered full time/part time basis (Universiti Sains Malaysia 2012).

Qualitative methodology is an approach that is appropriate for examining and reflecting the understanding the perception of social and human activities (UK Essays 2015). Creswell (2009) mentioned that qualitative methodology is a method of exploring and understanding the meaning conveyed by individuals or groups of individuals. Therefore, it is suitable to be used in analysing the perceptions (Creswell 2009).

Sharma and Kelly (2012) investigated students' perceptions of education for sustainable development in the accounting and business curriculum. The research was conducted at a business school in New Zealand. They found that the majority of the students perceived ESD as a "good thing." Most of the students strongly support the integration of sustainability in the business courses that they are studying. In addition, the research found that the students benefitted from the integration of sustainability into their courses as they can practise the sustainable business (Sharma and Kelly 2012).

A research conducted in Alabama and Hawaii to differentiate between college students' awareness and responsibility regarding sustainability. The study found that "commitment gap" rather than "knowledge gap" was more common among them (Emanual and Adams 2011). Apparently, all respondents care about sustainability was that they concern about wasteful consumption and pollution.

Meanwhile, at the University of Plymouth, a research was conducted through an online questionnaire survey, to obtain students' perceptions on, and their understandings of, and their attitudes towards, sustainable development and its related concepts and issues (Kagawa 2007). Majority of the respondents thought that sustainability is "a good thing." This indicated that their positive response was correlated with the degree of their familiarity to the concepts of sustainability (Kagawa 2007).

To review the implementation of sustainability programmes in a certain university, research on stakeholders' perceptions needs to be conducted. Therefore, to obtain the students' perceptions on MSc SCC programme, and its effectiveness in conveying the education of sustainable development, and to ensure that the delivery goals are met, this research was conducted to undertake an in-depth interview with seven graduate students from the MSc SCC programme, selected using purposive sampling. The data obtained was analysed using inductive content analysis method.

4 Findings and Discussion

To obtain the students' perceptions on MSc SCC programme, the data obtained from in-depth interviews were analysed using an inductive content analysis:

(a) **Is the MSc SCC programme that you are studying at USM effective in delivering the concept of sustainable development?**
In responding to this question, Respondent 2 answered as follows:

> MSC SCC is effective in giving understanding about sustainability in cities where all stakeholders need to bear all the responsibilities to ensure a sustainable life. (Respondent 2, female, aged 23)

Responding to the same question, Respondent 4 said:

> Yes, this course which i took gave me a lot of information about the sustainable development relating with my own self and environment surroundings, as well as giving an impact towards my daily practices. (Respondent 4, female, aged 28)

Respondent 5, reacted to the question saying:

> I think this programme is effective in conveying the information about sustainable development. I became more focused about the issues pertaining to sustainability surrounding my neighbourhood. For example, I have established an action unit among residents in my neighbourhood to prevent house-breaking crimes. This action unit was my manifestation as an outcome from my following my study during MSc SCC. Here the importance of social participation needs to be emphasised by the local communities. Nowadays, residents are more concerned and more alert about the house-breaking crimes and they start to build a teamwork with one another for the mutual safety. (Respondent 5, male, aged 43)

Respondent 7 expressed his opinion saying:

> In my opinion, MSc SCC course is a good platform to understanding the issues and social problems in cities based on various contexts such as community development, poverty, community responding towards infrastructure development, and so on. This course also discussed various suggestions for solving problems pertaining to these issues. However, the solutions need to be seen in the context of the locality. In the context of practising the sustainability

> practices in daily life, it depends on the individuals. Based on my understanding, this course is effective in giving knowledge and understanding about sustainability, but not for making the changes of an individual's lifestyle. It is because, to change a lifestyle is a complex process and influenced by circumstances in the environment. So, yes, this course is effective in giving understanding about sustainability issues but, it is not easy to practise it in daily life. (Respondent 7, male, aged 25)

Overall, it is clear that MSc SCC programme is effective in conveying knowledge about sustainable development. Based on the information obtained, the students were able to identify their role very well as a stakeholder in the community. This is because one of the respondents has taken the best action by forming an action unit to ensure the security and the safety of his neighbourhood. This shows that the MSc SCC programme has trained their students well, with an outstanding leadership skill sustainably. Besides, it is indication that the students have become more alert and aware with their surroundings, and they try to maintain the sustainability circumstances. In fact, the multi-stakeholder approach is one of the elements for implementing transformative ESD (Filho and Brandli 2016). Internal campus community and external parties, should play their role in the multi-stakeholder processes and engagement to accelerate the sustainable university projects (Filho and Brandli 2016).

Even though some of the respondents claimed that the MSc SCC programme is quite difficult to be transferred into daily practices, as it is more complex than just the knowledge that they have gained about sustainability through this programme. However, some of the other students still cannot relate the knowledge to their real life, and their surrounding environment. Apparently, ESD is not only the knowledge about sustainability obtained by the students, but also about how they try to really understand and relate it into practising it in real life.

On the other hand, the knowledge obtained from the MSc SCC programme also educates the students to be involved in solving community's problems. The should the value based-education in this programme to help solve the community's problems regarding emerging issues. This will show that the curricula implemented under the ESD have successfully linked education to the communities. If that is the case, then the students have been trained to participate in solving communities' problem using their critical thinking skills and communication skills.

(b) **How about your opinions with the way of sustainability were packaged in MSC SCC and the way it is being conveyed to students?**

Expressing her opinion in response to the question asked, Respondent 4 said:

> MSc SCC course is complete, consists all of sustainable development elements from aspects of community, economy and environment. If it is being practised, it is complete and adequate. Nevertheless, it needs to be added, so that, it will give a clear picture in practising the sustainability practices. Delivering information about sustainability is important in order to provide the students with introductory information. Thus, students will know the basic of sustainability. Further, fieldwork, community-engagement programs or other outdoor activities need to be intensified to enable the sustainability practices will be learned outside the classroom. (Respondent 4, female, aged 28)

To respond to the question asked, Respondent 5, gave his opinion by saying:

> MSc SCC is assumed as a complete package because it comprises, knowledge about sustainability in cities as well as communities. This had been proven by mini thesis project which all the students are compulsory to be passed. All students had been asked to do fieldworks relating to local sustainability issues. In looking for the data, students learned a lot the precious knowledge which they will not be able to get it if they did not take this course. During presentation sessions and viva, students had been rained with challenging questions by lecturers to make sure that we really understand the sustainability that had been taught during the program. However, the best sustainability learning method nowadays is 'Problem Based Learning' (PBL). This method is different from the conventional method as it focused on the deductive (overall) before goes to the inductive (specific) matters. Through old method (conventional), the students will be exposed with all the information about sustainability before they will be asked to overlook at certain issues. Hence, through this PBL method, students will be exposed to the problems or issues first of all, then afterwards, they will seek for the solution based on the sustainability foundations framework. In context of solving problems, then, students will refer to the knowledge in this area. This method had been chosen in many of medical schools in United Kingdom. The same method needs to apply to sustainable development students which not only can be more than 'hands-on' method, but also teaching and learning must be more interesting and meaningful. (Respondent 5, male, aged 43)

In her response to the question, Respondent 6, explained:

> MSc SCC needs to add much more of sustainability related topics to make it more comprehensive. The learning process needs to be practising through group discussions to enable each individual can give their ideas about sustainability issues as well as the sustainability knowledge can be understood well. (Respondent 6, female, aged 28)

The respondents' opinions and explanations showed that the MSc SCC programme was well packaged and has been successfully delivered by the educators. The students can understand the sustainability aspects of community, economy and environment very well. The only challenging part is to give a clearer picture and to put into practice these aspects of sustainability. This is because it is easier to learn about sustainability than putting sustainability into practice in real life.

Recently, more interactive learning methods are gaining more attention from the students compared with the traditional lecturing learning method. The students wanted to experience the sustainability activities outside the classroom. These activities need to be intensified within the scope of study. The course needs to integrate outdoor activities such as fieldwork, community-engagement programmes or other outdoor activities into the theoretical aspects of the sustainability concepts taught in the classroom. All of these activities could be intensified using with PBL method of teaching, so that, they will be killing two birds with one stone, participating in outside classroom activities, as well as learn to solve the problems in it.

5 Conclusion

The summary of results from in-depth interviews that have been conducted and recorded is presented in Table 2.

Table 2 Summary of in-depth interview on students' perception on Sustainable Cities and Communities Master Program (MSc SCC) of the School of Humanities, USM

Question	Result
1. Is the MSc SCC that you study at USM effective in delivering the concept of sustainable development?	i. Emphasise on the responsibilities of stakeholders and their responsibilities to play their role in sustainability ii. Knowledge from MSc SCC is effective in impacting on the students' daily practices iii. Students become more aware on the sustainability of their surrounding environment iv. MSc SCC provided the knowledge on issues and problems and how to solve them
2. What is your opinion on the way the course on sustainability was packaged in the MSC SCC and the way it is being conveyed to students?	i. MSc SCC needs to provide clearer picture on how to apply the sustainable development concepts in real life ii. New pedagogies are needed to be implemented in teaching and learning about sustainable development iii. PBL method seems to be important in disseminating the sustainability issues and problems iv. More case studies or situational analyses are needed to be intensified for deeper understanding

6 Limitation

Tracing graduated students from MSc SCC programme was quite challenging as most of them are no longer in the university and lost contacts.

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Knowledge and Opinions Amongst Youths in Secondary and Tertiary Education on Sustainable Development in Penang, Malaysia

Fatin Nabilla Ariffin, Theam Foo Ng and Munirah Ghazali

Abstract The implementations of sustainable development are a global trend and recently focus on Sustainable Development Goals (SDGs) 2030 Agenda. In ensuring the successful implementation of the 2030 Agenda, youths play a vital role in spreading awareness, understanding, knowledge and good practices in sustainable development. Thus, this exploratory research aims to determine the level of knowledge and opinions of Malaysian youth towards sustainable development concept and issues. Furthermore, the level of knowledge and opinions of youth on sustainable development is important for their involvement in future decision-making. A survey on sustainable development concept and issues was conducted in 2015 at selected secondary schools and tertiary (higher) educational institutions in the state of Penang, Malaysia. Cluster sampling method was used whereby 50 respondents were randomly chosen from each selected place. Data were then analyzed using the software IBM SPSS Statistic version 22. The findings illustrated the presence of high level of knowledge especially on environmental dimension of sustainable development. The high level of sustainable development knowledge was reflected in youth's opinions whereby they had positive and strong support for strengthening Malaysia's sustainable development efforts. The findings of this study can serve as a baseline data to the sustainable development research.

Keywords Sustainable development · Education · Knowledge · Opinions · Youths · Penang

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1 Introduction: Initiative Towards Sustainable Development

Sustainable development issues have always been great concerns to the world leaders and citizens especially after the publication of the Brundtland Report, an insightful text that laid the foundations of sustainable development for future generations. Consequently, there has been increasing discussion about the intentions and impacts of development to the world. Over the last thirty years, sustainable development has been defined in numerous ways, but the most regularly cited definition is from the 1987 Brundtland Report whereby sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). This indicate that economic, environmental, and social considerations have to constitute an integral part of the development process. In other words, as a constantly developing concept, sustainable development aims at improving individual's quality of life by integrating economic growth, social development and environmental protection together. Furthermore, to achieve sustainable development and overcome the challenges in the process, requires a global, collective and individual commitment (UNESCO 2005a).

Improving the quality of life indicate a change in our learning (UNESCO 2005a). In fact, one of the most powerful instruments to achieve sustainable development is through education. Therefore, in December 2002, the United Nations General Assembly had declared a Decade of Education for Sustainable Development (2005–2014) to integrate the principles, values, and practices of sustainable development into all aspects of education and learning, with the goal of promoting behavioural changes that will create a more sustainable future in terms of environmental integrity, economic viability, and a just society for current and next generations (UNESCO 2005b). During the Decade of Education for Sustainable Development (DESD), Education for Sustainable Development (ESD) has matured and grew (Laurie et al. 2016). Next, as a follow up to the DESD, in November 2014, UNESCO's Global Action Programme (GAP) was launched at the World Conference on Education for Sustainable Development. It focuses on creating and scaling up ESD activity at all levels in all areas of education, and in all sustainable development sectors to accelerate progress towards sustainable development (UNESCO 2015). Because of DESD and GAP, there is a growing global recognition of ESD as a crucial factor for sustainable development.

Meanwhile, Malaysia has attempted to introduce various regulatory measures especially in education to balance the goals of socio economic development with the maintenance of good environmental condition (Foo 2013). According to Saadatian et al. (2011), Malaysia is ranked ninth among 133 countries on efforts taken to reduce environmental stress on human health and ecosystem protection. The authors further states that Malaysia has implanted sustainable development in its policies, vision, mission and planning process. Moreover, recently, Malaysia has made a commitment to support and implement the 2030 Agenda for Sustainable Development. In terms of formal education, environmental education had been introduced in the Malaysian education system since 1982 (Said et al. 2007). In secondary schools (for 13–17 years old), environmental education is integrated in subjects such as geography, science, moral education and life skills (Said et al. 2007). Furthermore, other bodies such as the Department of Environment, non-governmental organizations, and industries have involved themselves in implementing environmental education to the students and to the public through activities like talks, workshops, seminars, exhibition, radio shows, competitions, clean-up campaigns, camping and tree planting (Said et al. 2007).

On the other hand, youths or young people have been recognized by the United Nations (UN) and global leaders as the agent of change and that they have a critical role to play in the successful implementation of the sustainable development goals. Nowadays, with platform provided by the UN, youths are voicing out on critical issues that require change for the common good. In any democratic society, youths should have opportunities to take part in the decision-making processes that affect them and their society as they have valuable contributions to make to these processes (Youth Affairs Council of Victoria 2004). Without a doubt, society, policy makers, and those in positions of power should involve youths in decision making process in ensuring their country and the world to achieve Sustainable Development Goals.

Despite government's commitment and various efforts and initiatives to address sustainable development issues through ESD and GAP, many states including Malaysia is still facing immense challenges in ensuring sustainable development by looking at the stressful environmental condition, extreme poverty, unsustainable consumption and production and many more. According to Michalos et al. (2015), one of the challenges that has been identified during the DESD is that of monitoring and evaluation especially in assessing whether efforts invested in ESD can lead to positive learning outcomes in students. Besides, there has been limited study that ESD can influence knowledge, attitudes and behaviours that is in line with sustainable development (Michalos et al. 2012). Therefore, this study attempted to measure the level of knowledge towards sustainable development amongst youth as well as their opinions on sustainable development efforts in the international and national level.

2 Knowledge and Opinions on Sustainable Development

Knowledge is important for environmental awareness of individuals (Zareie and Navimipour 2016). In other words, knowledge is a prerequisite for awareness of individuals. Also, knowledge is the ability of individuals to understand and evaluate the impact of a society on the ecosystem (Zareie and Navimipour 2016). Similarly, Fahlquist (2009) stated that individual's environmental knowledge will affect their level of awareness on the environment and its problems and, therefore, be more motivated to act responsibly toward the environment. Meanwhile according to Lavega (2004), the three sustainable development components play a vital role on the impact that students will have throughout their lives theoretically and practically. Besides that, Aminrad et al. (2013) also mentioned that many of social scientists believed that knowledge and attitude are linked to each other where attitude if further, is connected to the behaviour of a person.

There were several past researches that has examines the effect of knowledge on attitude. A study by Sykes et al. (2002) on attitudes and knowledge of significant environmental concepts of students from several states such as Australia, Brunei, China, India, Japan, New Zealand, Singapore and Thailand revealed that the ozone layer and greenhouse effects are the most known concepts across all nations while the least known concepts were sustainable development, biodiversity and carrying capacity. Likewise, a study amongst students in Sabah, Malaysia studied respondents' environmental knowledge and attitudes. This study found that students in Sabah do have a high level of environmental knowledge though lacked in the areas of climate change and the rise of carbon dioxide in the atmosphere (Harun et al. 2011).

On the other hand, Aminrad et al. (2013) in their study amongst secondary school students in Malaysia however found that students were highly aware on environmental issues and showed positive attitudes about environmental issues. Meanwhile, a study by Ali (2015) revealed that secondary school students in Terengganu, Malaysia showed low levels of environmental awareness and only a moderate attitude towards the environment. Moreover, the author also suggested that qualified educators should be employed to address the low level of awareness.

To date, there are several studies on knowledge towards sustainable development that have been conducted both internationally and nationally with mixed results from the studies. According to Michalos et al. (2015), there yet been an effort at developing any standardized measures for evaluation of the outcomes of ESD. Hence, this study is to acquire proof of changes in level of knowledge among students that might be consistent to current investments in ESD.

In terms of opinions of young people regarding sustainable development and ESD, few studies have been conducted to date especially in Malaysia. For youth, participation can lead in increased knowledge and skills, more social opportunities and a rewarding sense of community connection (Youth Affairs Council of Victoria 2004). Their opinions also could help in achieving the 2030 sustainable goals as they offer valuable and distinct viewpoint. Arnold et al. (2009) conducted an interview research with young environmental leaders in Canada to discover their motivation in joining environmental activities. The results found that respondent's main influences in joining environmental action were their parents, childhood experiences, peers, role models, teachers, youth organizations and lastly conferences or gatherings. The study also suggested that these influences are vital to the development of youths in becoming leader in maintaining sustainable development. Whereas Jaafar et al. (2015) focused on perception of secondary school students toward sustainable conservation programmes in Lenggong Worlds Cultural Heritage (WCH). The study found that positive perceptions do have a positive effect on youth's involvement in promoting and supporting Lenggong WCH while negative perceptions affected youth's sense of belonging.

Although there were a few studies focusing on sustainable development issues, it seems that studies on three components of sustainable development are still limited especially in Malaysia. Thus, this gap of knowledge further increases the need to establish new information on the level of knowledge and opinions of youth relating to sustainable development which could help guide the state and educational institutions in sustainable development decision-making.

3 Method of the Study

In this study, descriptive and correlational design was used to evaluate respondent's demographic background and knowledge and opinions regarding sustainable development. The research design of this study will be using primary data obtained by means of questionnaire answered by randomly selected respondents. Respondents for this study are youth aged 15–25 years old in secondary schools and tertiary education students in higher educational institutions (HEIs) within the state of Penang, Malaysia. Figure 1 is the map of Penang as the study area. Penang is situated the northern region of Peninsular Malaysia. The state has a total area of approximately 1030 km^2, consisting of two separate areas, namely the Penang Island and Seberang Perai on the mainland. In addition, the state has five administrative districts, that are the North-East district and South-West district on Penang Island; and the Northern Seberang Perai district, Central Seberang Perai district and Southern Seberang Perai district in Seberang Perai (Penang Geographic Information Centre 2019). Figure 2 is the map of the five administrative districts.

Penang has been chosen as the study area because this state has been heavily involved in implementing sustainability amongst its people. Furthermore, Penang aspires to become the first green and sustainable state in Malaysia (Portal Rasmi Kerajaan Negeri Pulau Pinang 2015). Respondents were acquired using the cluster sampling method and respondents were then randomly selected during the survey. Furthermore, the questionnaires were distributed to each administrative district in Penang. Finally, a total of 11 secondary schools and 6 HEIs have been chosen to be the representative sample for this study. The survey was conducted between June and November 2015.

The questionnaire form was uploaded online and students in HEIs were asked by researchers to fill in the form using tablets and computers. This method was used as it is environmentally friendly and cost-effective method for collecting information. Meanwhile, data collection for secondary schools was conducted by distributing questionnaire by hand. The questionnaires were distributed to students aged 19 until 24 years old. It is important to note that, the survey was carried out during the student examination period. While in secondary school, researchers were only allowed to distribute questionnaires to Form 4 students only (age 16 years old). Researchers were not allowed to interfere with Form 3 and 5 students (age 15 and 17 years old accordingly) because the schools' management did not want to interrupt their learning session as they will take an important national examination soon. Hence, it is quite difficult to find many respondents for this study. And then, we finally got only 772 respondents out of the total number of respondents planned.

Fig. 1 The state of Penang—the study area (OpenStreetMap 2017)

Altogether, 772 respondents were interviewed using the structured questionnaire survey. The questionnaire was adapted from various surveys conducted elsewhere on the topic of sustainable development and sustainability including a survey conducted by UNESCO Office in Venice (2015) on Mediterranean youth's responses towards sustainable development and current crisis. The questionnaire was divided into several parts covering respondents' demographic information, respondent's knowledge and opinions on sustainable development.

The purpose of the survey is to identify the knowledge of youth on sustainable development concepts and their opinion on the government's efforts towards sustainability. In addition, this survey would provide an indicator for policy makers to take note on youth's opinions and participation in sustainable development efforts. According to Erikson and Tedin (2015), the study of public opinion is justified by the simple belief that democratic institutions should result in government decisions that reflect the people's point of view. In addition, Keulen et al. (2015) proposed that educating youth is most effective when it is based on generating experiences and active involvement in the initial policy making and political decision process not only as a participant in programs and projects.

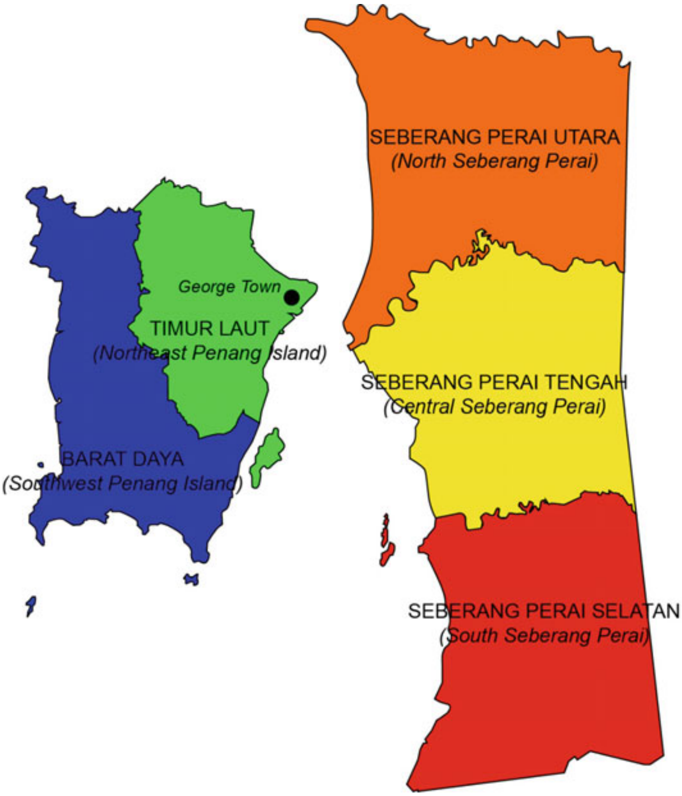

Fig. 2 The five districts of Penang (Dreamtrooper 2014)

To measure respondent's level of knowledge and opinions, sixteen items on knowledge and fourteen items on opinions were presented to the respondents. In knowledge section, the first two items were measured using the multiple-choice question. Meanwhile the rest of the items in knowledge section were measured using 3-point Likert scale where 1 = agree; 2 = not sure and 3 = disagree. On the other hand, in opinion section, fourteen items were asked using a 5-point Likert scale where 1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = strongly agree.

A Cronbach's Alpha test for internal consistency revealed a coefficient of 0.738 and 0.943 for items regarding knowledge and opinions respectively. According to Tavakol and Dennick (2011), there are different reports about the acceptable values of alpha, ranging from 0.70 and 0.95. Thus, the internal consistency reliability of the measures used in this study is acceptable as both variables scored above 0.7. Data were analysed using the SPSS software. Data then were summarised using means and standard deviations.

4 Results and Discussion of the Study

4.1 Demographics

Details of respondent's demographic information are presented in Table 1. It includes information on gender, ethnicity, and field of studies. The data is presented in the form of percentage (%).

In terms of gender of the school students, 50.5% were male respondents and 49.5% were female respondents. Meanwhile in terms of school student's ethnicity, Malay ethnicity made up 59.3% of the total respondents while Chinese ethnicity made up 30.1%, Indians made up 9.2% and lastly other ethnicity made up 1.4% of the total respondents. This shows that the demographics of this study are represented by multiple ethnic groups that exist in Penang. Besides that, majority of the school students were in the science field of studies with 80.9% while the rest of respondents were in arts field of studies with 19.1%.

On the other hand, in terms of gender of the HEIs student, 45.4% were male respondents and 54.6% were female respondents. Whereas in terms of HEIs student's ethnicity, Malay ethnicity made up 17.0% of the total respondents while Chinese ethnicity made up 58.3%, Indians made up 21.6% and lastly other ethnicity made up 3.2% of the total respondents. Lastly, majority of the HEIs students were in the arts field of studies with 62.8% while the rest of respondents were in science field of studies with 62.8%. The result from this study provides a view of young and educated Penang population on global and national sustainable development issues.

The youth form a large segment of the total population internationally, nationally and locally. Besides that, youths have an important role to play in shaping the direction and future of Malaysian involvement in global sustainable development agenda. According to Leong et al. (2012), youths are a critical demographic group to engage since they have diverse and numerous roles in the country's political, social and economic landscapes. Thus, the respondents' view could be considered relevant

Table 1 Composition of survey samples

School students			HEIs students		
Gender (%)	Male	50.5	Gender (%)	Male	45.4
	Female	49.5		Female	54.6
Ethnicity (%)	Malay	59.3	Ethnicity (%)	Malay	17.0
	Chinese	30.1		Chinese	58.3
	Indian	9.2		Indian	21.6
	Others	1.4		Others	3.2
Field of studies (%)	Science	80.9	Field of studies (%)	Science	37.2
	Arts	19.1		Arts	62.8

information that represents the Malaysian youths about sustainable development issues in Malaysia.

Meanwhile, Helferty and Clarke (2009) in their study on student-led campus climate change activities mentioned that HEI students are central in awareness-raising campaign on campuses and they also have a unique perspective to contribute to campus climate solutions. Clark further said that HEI students are likely to create their own strategies to guide friends on behavioural change or implement mechanisms to lessen climate change issues. Furthermore, engaging key groups in decision-making and co-develop solutions to address development challenges can help the country towards achieving the global 2030 Sustainable Development Goals Agenda (UN Women 2016). In addition, to ensure that the new development agenda is in fact changes our nation and provides a more sustainable world, participatory youths are needed. Hence, results from this study may help the key actors in sustainable development especially the government and youth organizations to develop effective initiatives and strategies especially in formal education.

4.2 Knowledge

The first two knowledge items were a multiple-choice type of question concerning general knowledge on sustainable development. The data is presented in Tables 2 and 3.

Based on survey results, very few respondents agreed that social and economy are part of the sustainable development dimensions: 34.2 and 45.9% respectively.

Table 2 Components of sustainable development

Item	Yes (%)	No (%)
Environment	85.9	14.1
Social	45.9	54.1
Economy	34.2	65.8

Table 3 Issues and challenges of sustainable development

Item	Yes (%)	No (%)
Water	63.4	36.6
Energy	41.8	58.2
Health	55.6	44.4
Agriculture	23.7	76.3
Biodiversity	20.7	79.3
Climate change and disaster risk management	32.5	67.5
Population and poverty	16.8	83.2
Production and consumption	11.5	88.5

Meanwhile, majority of respondents (85.9%) concluded that environment is part of the sustainable development components. The result shows that there is still some misunderstanding regarding the dimension of sustainable development. According to Giddings et al. (2002), sustainable development is usually presented as being divided into three spheres which are the economy, environment and society and they are interconnected. The authors also mentioned that in most discussion about sustainable development, either the environment or the economy is given priority. Whereas, Jenkins and Jenkins (2005) argued that sustainable development involves proper balance between the three dimensions and when it becomes inappropriately skewed such as toward economic growth, then the other dimension can become stressed and even threatened. Therefore, ESD is needed to help address this appropriate balance especially amongst the youths so the youths would not assume that sustainable development is efforts to protect the environment only.

On the other hand, the respondents agreed that water (63.4%) and health (55.6%) are the issues and challenges in sustainable development. Currently, there is lots of exposure regarding water scarcity and health issues especially in the least develop countries by the media and the internet. Therefore, the exposure may have affected the respondents in choosing water and health as issues of sustainable development. Furthermore, with water pollution and emergence of new diseases, it is not surprising that many respondents chose water and health as issues in sustainable development. Besides that, most of the respondents agreed that population and poverty and production and consumption are not part of the issues in sustainable development with a percentage below 20%.

Next, fourteen items regarding deep knowledge on sustainable development with a 3-point Likert were asked to respondents. The result is presented in Table 4.

Referring to Table 4, most respondents answered correctly on the item number 5, 6 and 14 with 72.4, 75.4 and 76.5% respectively. While item number 9 and 10 showed the least agreed percentage with 24.7 and 30% respectively. This result is understandable because item number 9 and 10 mentioned about agreement that might not be familiar among the respondents. Moreover, looking at the means result, it can be said that the level of knowledge among youth is high. Thus, there is evidence that some progress in sustainable development has been made, but much more remains to be done especially familiarizing youth with a deeper knowledge of sustainable development. In addition, the education curriculum must provide a quality education especially implementing ESD in the curriculum at all level of education so that no one will be left out. Further, we can follow countries that were reported to have an excellent ESD schools such as Australia, China, England, Sweden and the Netherlands. Laurie et al. (2016) stated that from studies in 14 countries (Australia, Belgium, Canada, China, England, Estonia, Finland, Germany, Japan, Mongolia, Peru, Scotland, Sweden, and the Netherlands), students of ESD schools develop better critical thinking skills, deeper understanding of the topics under study and stronger research skills aside from other excellent traits.

Table 4 Level of knowledge on sustainable development

Item	Agree (%)	Not sure (%)	Disagree (%)	Mean
1. SD is a development that meets the need of the present without compromising the ability of future generations to meet their own needs	68.8	27.0	4.1	1.35
2. ESD is a vision of education that aims to cultivate the community to take responsibility on creating a sustainable future	62.7	33.8	3.4	1.41
3. Erratic change of rainfall patterns can lead to increased heavy floods and extreme droughts	64.0	29.8	5.3	1.41
4. Extreme hurricane and storm events are effects of climate change	58.1	33.0	8.0	1.49
5. Poverty is often accompanied by unemployment, malnutrition, illiteracy, exposure to environmental risks and limited access to social and health services	72.4	21.2	6.0	1.33
6. Overpopulation will affect the country's population needs and the management of natural resources	75.4	19.3	5.3	1.30
7. Enhancing corporate environmental and social responsibility are integral to sustainable production and consumption	57.1	37.1	5.8	1.49
8. Unsustainable patterns of production and consumption are depleting natural resources, creating waste and causing environmental pollution	67.0	28.2	4.8	1.38
9. Montreal Protocol is an international agreement that is designed to protect the Earth's ozone layer	24.7	70.1	5.2	1.80
10. Kyoto Protocol is an international agreement that is used to reduce the greenhouse gas emissions to tackle global warming	30.0	65.8	4.0	1.74
11. Environmental Quality Act 1974 is an Act related to prevention, abatement, control of pollution and enhancement of the environment	48.9	46.8	4.0	1.55
12. National Environment Policy is created to continue the development in economic, social and cultural as well as to increase life quality of Malaysians through securing the welfare of the environment and sustainable development	46.7	48.0	4.8	1.58

(continued)

Table 4 (continued)

Item	Agree (%)	Not sure (%)	Disagree (%)	Mean
13. National Climate Change Policy acts as a framework to move the government agency, industries, communities and stakeholders in facing the challenges of climate change holistically	43.1	50.2	5.3	1.62
14. Human activities are the cause of global warming and climate change	76.5	15.3	5.4	1.27

4.3 Opinion

In this section, opinions among respondents were investigated by the responses of 14 questions on opinion towards sustainable development policies and initiatives in Malaysia.

In general, respondents showed strong support and recognition for domestic actions and policies to address sustainable development issues scoring an above average for all items. However, there are three items that scored below a 4 point which are item 7, 9 and 13 with mean score of 3.82, 3.98 and 3.95 respectively. Vasi (2012) addressed that study on environmental attitudes has steadily shown that a greater part of the nation is concerned about environmental problems. Vasi continued by saying that these great concerns are accompanied by strong support for domestic and global action to protect the environment. Thus, strong support shown from the result of this study could probably due to high level of knowledge from the Malaysian youth.

Based from the results in Table 5, item 6—'create a green environment in college', recorded the highest mean compared to other items. This shows that respondents also supported efforts toward green campus or sustainable universities. In 2003, United Nations Environment Programme (UNEP) had published a document—Greening Universities Toolkit as an initiative to support and transform universities into green and sustainable campus. Several HEIs in Malaysia such as Universiti Sains Malaysia (USM), Universiti Kebangsaan Malaysia (UKM), Universiti Malaya (UM) and Universiti Putra Malaysia (UPM) have participated in the efforts to build and provide a sustainable and environmentally campus for its community (Mohammad 2011). Years later, according to the UI GreenMetric, a global university ranking system that measures university's commitment in developing an environmentally, University Putra Malaysia (UPM) was placed at the top spot along with other universities in the United States and United Kingdom and also named as Asia's best green campus (Malay Mail Online 2016). The success of domestic HEIs placed at the top spot indicates the government, university management and university students' commitment and initiatives toward sustainable development. Thus, students may feel more familiar with greening the campus. Meanwhile, the lowest mean recorded was item

Table 5 Opinions on sustainable development in Malaysia

Item	Mean	Std. Deviation
1. Each youth must practice a sustainable lifestyle	4.14	0.93
2. Youth need to promote sustainability and sustainable development	4.03	0.86
3. Youth must be willing to change their lifestyle towards sustainable development	4.09	0.85
4. Youth should cooperate with the government in building strategies for sustainable development	4.09	0.86
5. Create association/student club related to sustainability in school/college	4.02	0.86
6. Create a green environment in college	4.33	0.83
7. Integrate elements of sustainability into curriculum at all levels of education	3.82	0.92
8. The government should increase youth leadership in sustainability issues	4.01	0.85
9. Implement sustainability elements in every national policy development	3.98	0.86
10. Government and society should cooperate in maintaining the ecosystem in the country and use natural resources efficiently	4.15	0.88
11. The government should consider the opinion of the youth in building a policy for sustainable development	4.06	0.90
12. Each nation must mobilize their youth to develop their understanding of challenges in sustainable development nowadays	4.04	0.87
13. Each country should develop Sustainable Development Goals (SDGs), which emphasizes the role of youth in achieving a sustained worldwide	3.95	0.91
14. Youth ministry and NGOs around the world should be able to encourage and assist the youth to acquire knowledge and skills necessary to promote sustainable development	4.08	0.88

7—'integrate elements of sustainability into curriculum at all levels of education'. Further study should be carried out regarding this matter before our education curricula starts to implement sustainable development elements in the education system.

5 Conclusion: The Effectiveness of the ESD Program and Youth's Role in Sustainable Development Agenda

In general, this study has shown that the level of knowledge on sustainable development amongst youths in Penang is well-developed in many of the youths. However, majority of youths lacked knowledge and understanding regarding components of sustainable development. For instance, large groups of students did not know that economic and social dimension are part of sustainable development components. This is a worrying problem to us. Probably the government should include more of these two components in the ESD program that has been taught at school instead of focusing only on the environment component.

Meanwhile, the finding also showed that youths had positive and strong support in strengthening Malaysia's involvement in building better sustainable development policies and mass mobilisation of youth towards sustainable development lifestyle. With strong support and positive attitude from the youths, it is not possible that Malaysia can achieve the 2030 Sustainable Development Agenda.

Clearly, from the result of this study, ESD program in the education system has had a good impact on the level of knowledge and affecting positive opinions on sustainable development amongst young people in Penang. Therefore, program such as ESD in Malaysian education system should be continued with enhancement of existing syllabus. For instance, instead of focusing only on formal education, we should also encourage young people to participate in our community so that they can understand the importance of sustainable development for their future. Their active participation brings valuable and unique perspectives to the community. Furthermore, it is empowering for youths to have their opinions sought and recognised as valid (Youth Affairs Council of Victoria 2004).

This study that was conducted in Penang is not meant to be an indicator of the level of understanding and representing the opinions of youth throughout Malaysia but can serve as a comparison to other related research. Results obtained from this study have shown the progress of sustainable development initiatives in Malaysia and it can be used as baseline data for further research related to sustainable development and youth in Malaysia. Furthermore, data from this study provide an insight to policy makers in decision-making process in planning better actions in promoting sustainable development and building better sustainable development policies for Malaysia.

Since the study was conducted in Penang, it is recommended that this study to be carried out at different parts of Malaysia to get more accurate data regarding youth in Malaysia. Besides that, more studies on the level of technical knowledge on sustainable development is needed as this study only provides the level of general understanding on sustainable development. In addition, referring to the literature review, most studies on sustainable development were about the environmental issues. Thus, future researchers can study on sustainable development issues instead of focusing only on environment pillar of sustainable development.

Clearly, the young citizens play a vital part in helping the world states to meet the seventeen Sustainable Development Goals by 2030. Further, engaging youth with programs and initiatives related to sustainability will create awareness, understanding, knowledge and possibly positive attitude towards sustainability. Besides that, schools and universities can be a powerful tool in promoting sustainable development to youths by integrating the principles and practices of sustainable development into all aspects of education.

In addition, youths should be modelled as centres of the community for promoting sustainability. Thus, the government and NGOs should work together in focusing more on advancing policy and promoting education for ESD in their curriculum and outside of the class activities where youths can also share their fresh ideas and actions on sustainable development issues and challenges. Also, empowering and mobilizing youth is needed to accelerate progress towards sustainable development in line with the Global Action Programme (GAP) and ESD. Moreover, local educational schools and institutions could become instrumental in training, helping and preparing youths to make needed and meaningful contributions to sustainable development. Nyoni (2009) commented that that schools and other formal educational institutions play a vital role in shaping the attitudes and values of youth. Finally, it is also recommended that the government, NGOs and the public give financial support to educational activities for youth. For instance, activities training workshops, seminars, and conferences will guide the youth to interact and exchanging ideas with other youth and professionals from different background (Ogendi and Ong'oa 2009).

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Measuring the Effectiveness of Sustainability-Related Course Towards Strengthening the University's Sustainability Strategy in Teaching and Learning Programmes

Theam Foo Ng, Maurice Ian Wee, Fatin Nabilla Ariffin, Ahmad Firdaus Ahmad Shabudin and Mohd Sayuti Hassan

Abstract Mainstreaming sustainability into the education system is a key strategy for Universiti Sains Malaysia (USM) to strengthen its position as one the custodian institutions in the global sustainability agenda. In pursuit of becoming a sustainability-led university, USM has undertaken numerous transformational adaptations, especially in teaching and learning (T&L) programmes that emphasize principles and best practices of sustainable development. Therefore, an undergraduate course, Sustainability: Issues, Challenges and Prospects or code-named WSU 101, was introduced by the Centre for Global Sustainability Studies (CGSS), since 2012. Through multi-research approaches, this paper reviews USM's strategies in integrating key sustainability drivers into T&L programmes and evaluates the effectiveness of this initiative through the course evaluation. The findings found that several sustainability-related courses have been established and offered to postgraduate and undergraduate in USM. Evidently, the inclusion of sustainability-related courses like WUS 101 into the university curriculum has significantly improved awareness among students. The information garnered is useful for USM to strengthen its institutional strategies, besides it can act as baseline data for the implementation of education for sustainable development (ESD) by institutions worldwide.

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Keywords Sustainability · Sustainable development · Awareness · Knowledge · Teaching · Learning · Education · Assessment

1 Introduction

The necessity to educate and sow the seed of intellectual awareness about sustainability is unquestionably very important in the wake of the global environmental crisis. Fundamentally, the concept of sustainability entails considerable obligations of present generations to consider the satisfaction of needs of future generations (Guillen-Royo 2016). Future generations have the same natural rights as present generations; hence they have equitable right to inherit the legacy of a biologically diverse, resilient, life-supporting planet and a social world equally supportive of human diversity and creativity. A profound transformation of intellectual and action is prerequisite for sustainable development, and this can be achieved with the right knowledge, skills, values, and attitudes. Therefore, education is recognized as one of the key instruments for promoting sustainable development; the required shift in the thinking, values, and actions of individuals and institutions calls for efforts to place sustainability at the heart of all kinds of education.

Education for Sustainable Development (ESD) is a well-established and holistic approach to sustainability which originally had its roots in international conferences in the 70s. The UN Conference on the Human Environment (UNCHE) held in Stockholm, Sweden in 1972 and the UNESCO-UNEP Intergovernmental Conference on Environmental Education held in Tbilisi, Georgia (the former Soviet Union) in 1977, displayed a growing interest in conservation issues worldwide and laid the groundwork for global environment governance (Wals and Kieft 2010). Following this, Agenda 21, an all-inclusive, non-binding blueprint concerning sustainable development that emphasizes the role of local government in fostering partnership between community, local authority, and private sector, was introduced at The Earth Summit in Rio de Janeiro in 1992 (Koch and Grubb 1993; Fowke and Prasad 1996; Niss 2002). In order to bolster ESD as a motor for change, the United Nations General Assembly in 2002, declared the Decade for Education for Sustainable Development (DESD) 2005–2014 which accentuates the integration of principles and practices of sustainable development into all facets of education and learning (Venkataraman 2010). The adoption of DESD has ever since influenced the institution of new policies and strategies in local governments and engagement of relevant stakeholders on matters related to sustainable development, thus allowing the creation of new tools and resources for the implementation of ESD (Mula and Tilbury 2009). The adoption of the 2030 Agenda for Sustainable Development ("2030 Agenda") by all member states of the United States in September 2015 stands as a clear testament to their commitment to sustainable development initiatives and to the 17 UN Sustainable Development Goals (UNSDGs) the framework outlined for the next 15 years (UNDP 2016).

According to Wehrmeyer and Chenoweth (2006), the implementation of sustainable development by society is partly determined by individuals being informed and educated about the interactions of environmental, social and economic issue. The Malaysian policy framework recognises that education development plays an ever-growing role in building a sustainable, resilient and competitive society (UNESCO 2011). In a report on ESD implementation in East and Southeast Asia, Didham and Ofei-Manu (2012) stated that policy endorsement for ESD in Malaysia is most prevalent in environmental education and the National Policy on the Environment. In Malaysia, ESD implementation is jointly managed by the Curriculum Development Division of the Ministry of Education and the Department of Environment of the Ministry of Natural Resources and Environment (Mathe 2014).

Higher education institutions (HEI) like universities have an integral responsibility to transform sustainable development from abstract to reality by introducing and integrating ESD into the curriculum across the courses offered. Universiti Sains Malaysia (USM) has always been the spearhead of sustainability among universities in Malaysia through several milestone initiatives. In parallel with the establishment of DESD, USM was accorded as a Regional Centre of Excellence on Education for Sustainable Development (USM-RCE) by the United Nations University in Nagoya University, Japan, on 29 June 2005, the only one in the Asia Pacific region (Universiti Sains Malaysia 2008). The USM-RCE inception has created a stimulus for sustainability implementation and provided a platform for USM to engage with the community (Sanusi and Khelghat-Doost 2008). In 2008, USM was awarded the Malaysia's Accelerated Programme for Excellence (APEX) status, a far-reaching higher education transformation roadmap which vision underpins sustainability targets (Razak 2009).

The integration of sustainability into the heart of a university's system demands an undivided system enterprise that bridges major sustainability challenges on one end with different educational approaches on the other. The sustainability challenges have to be determined very thoughtfully by each institution. Presently, the mainstreaming of sustainability across the entire of operations of USM followed a sustainability integration model which is encapsulated in Fig. 1. The model incorporates the major sustainability challenges founded on three pillars of sustainability, viz. economy, society and environment. Meanwhile, the educational approach instituted three pillars of education, viz. teaching, research, and community engagement. The specific sustainability challenges to be attended are itemized in the middle box. This offers diverse combinations of engagement for any given sustainability issue through a variety of educational approaches. Besides, this model allows an entry point for all sections of both academic and non-academic staff to be involved in sustainability activities, regardless of the section of the university for which they work.

In its vision to become a world class sustainability-led university, Center for Global Sustainability Studies (CGSS) at USM has developed a formal curriculum called WSU 101 (Sustainability: Issues, Challenges and Prospects), an elective sustainability course for undergraduates (UNESCO Green Citizens 2017). Students are exposed to the latest developments in the sustainability studies agenda through the study of global case studies and examples drawn from sustainability programme

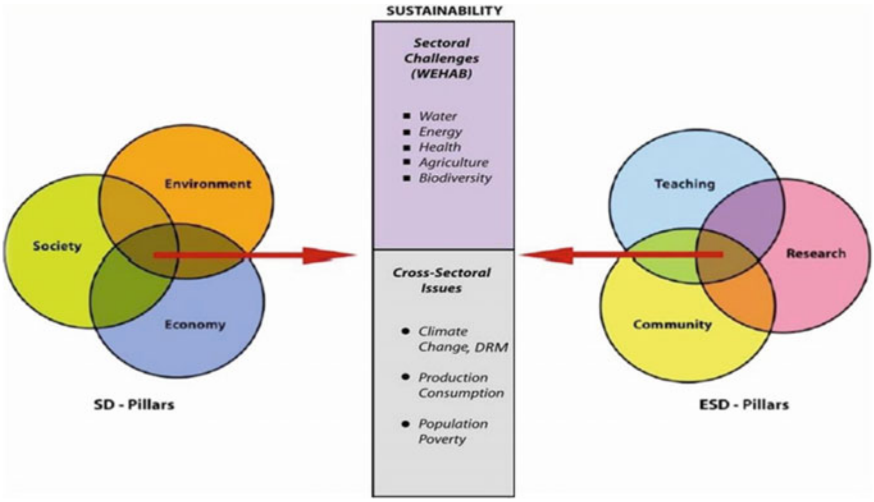

Fig. 1 USM's sustainability integration model

from around the world. At the end of the course, students are anticipated to be equipped with the skills needed for developing sustainability-oriented programmes. The course which was first introduced and offered in 2012 has been receiving encouraging response from students as average enrolment of 500 students is recorded every semester.

There are several studies to gauge the effectiveness of sustainability related courses worldwide. A study by Segalas et al. (2010) on the effect of sustainability courses offered to engineering students from five European universities concluded that students who previously viewed sustainable development as largely technologically related, started to consider social and attitudinal approaches to sustainability after attending the course. In another study, Connell et al. (2012) have revealed improvements in term of thinking skills with regards to sustainability among undergraduates attending sustainability-related curriculum. A study by May (2015) which focuses on a variety of perspectives, lectures and diverse instruction methods during the Climate Change Leadership course held at Uppsala University, Sweden were found to be the core contributor to effective strategies for success in sustainability education. Nonetheless, a study by Tuncer (2008) which compared the perception of two groups of students; with only one group enrolled in the environment-related course, did not find any significant difference between them.

Since the inception of WSU 101 into the university curriculum, not even a single study has been carried out to determine the impact of the course on students. Worryingly, the culture of rote learning among Malaysian students has been highlighted in several literatures which in particular denotes the students ability to only pose less-critical and factual questions in class due to the exam-oriented nature of education system in Malaysia (Hussin 2006; Idrus 2007; Campbell 2011). Several literatures on ineffective pedagogy highlights the need to measure and gauge the impact of a course on students. For that reason, the impact of WSU 101 on students must be first comprehended in such manner that better strategies can be design to embolden USM's involvement in sustainability in the future.

2 Methodology

A course assessment survey is pivotal to determine the effectiveness of the elective sustainability course, WSU 101 (Sustainability: Issues, Challenges and Prospects) on student awareness relating to sustainability and adoption of sustainable livelihoods in practice. The survey was carried out in two separate time frames; at the beginning (September 2015) and at the end (December 2015) of the course. The survey was administered to 409 undergraduates attending the course (WSU 101). The first survey was self-administered online via Google Docs and the respondents were asked to complete the questionnaire in one day. Although this method is relatively cheap and generates fairly fast results, it is essentially restricted to a population with internet access. Meanwhile, handouts were administered during the second survey (at the end of the course) for immediate evaluative responses. The ability to probe answers is limited when this method is employed. Nonetheless, respondent's anonymity is uncompromised.

The first survey questionnaire is made up of three main sections. The first section concerns the demographic background of the respondents (gender, age and ethnicity). The second section evaluates the general comprehension of respondents about the course, sustainability and sustainable development using multi-choice questions with check boxes and a 10-point Likert scale. The third section is a five-item test that measures respondents' knowledge, attitude and behaviours towards sustainability. Meanwhile, the second survey questionnaire is composed of four sections; the questions or contents featured in Sects. 1, 2 and 3 are reproduced from the earlier survey. The fourth section constitutes questions with a 10-point Likert scale to solicit useful views and suggestions from the respondents to help educators to acquire new strategies to improve the course. The garnered data were analysed using descriptive statistics and statistical functions with the aid of SPSS version 22.

3 Results and Discussion

(A) **Demographic of respondents**

A total of 409 students participated as respondents during the first survey. Table 1 illustrated the demographic of the respondents. The distribution of respondents by gender was 19.3% male and 80.7% female. The data implied that majority of the respondents (98.8%) involved were aged between 20 and 25 years whereas 1.0 and

Table 1 Demographic of respondents during the first survey

Demographic variables		Percentage (%)
Gender	Male	19.3
	Female	80.7
Age	19 and below	0.2
	20–25	98.8
	26 and above	1.0
Ethnicity	Malay	68.9
	Chinese	26.7
	Indian	2.4
	Others	2.0

Table 2 Demographic of respondents during the second survey

Demographic variables		Percentage (%)
Gender	Male	18.3
	Female	81.7
Age	19 and below	0.0
	20–25	98.8
	26 and above	1.2
Ethnicity	Malay	66.3
	Chinese	27.9
	Indian	3.4
	Others	1.0

0.2% of respondents fell within the age group of 18 years and above and 19 years and below, respectively. Malay composed more than half (68.9%) of the respondents, followed by Chinese (26.7%), Indian (2.4%) and respondents of other races or ethnicities (2.0%).

Meanwhile, a similar number (of respondents were garnered during the second survey (Table 2). However, there were little differences in terms of age and ethnicity variables. The distribution of respondents by gender was 18.3% males and 81.7% females. The majority of respondents (98.8%) involved were aged between 20 and 25 years old whereas only 1.2% of respondents fell within the age group of 26 years and above. There was no respondent aged between 19 and below involved during the second survey. Malay composed the majority (66.3%) of respondents, followed by Chinese (27.9%), Indian (3.4%) and respondents of other races or ethnicities (1.0%). Comparatively, the number of Malay respondents has slightly decreased during the second survey.

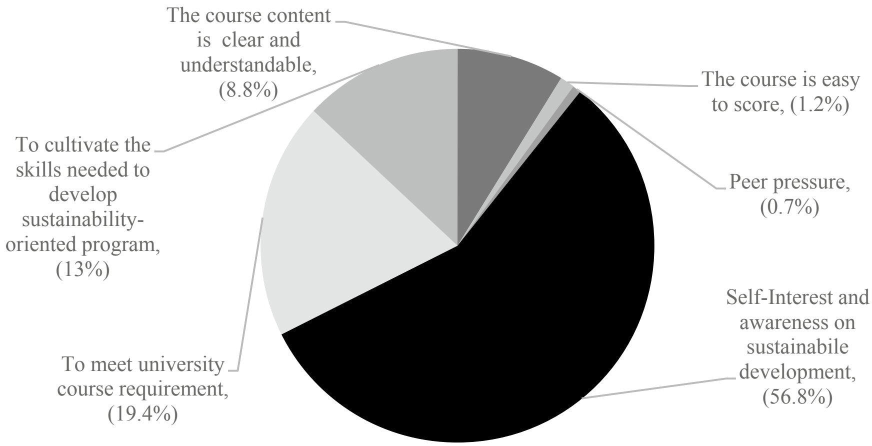

Fig. 2 Factors affecting students' individual interest in course (WSU 101) selection

(B) Factors affecting students' individual interest in the course (WSU 101)

The majority of respondents (56.8%) selected WSU 101 as an elective course because of their self-interest on subjects relating to sustainability and awareness on the importance to implement sustainable development. Contrarily, peer pressure was regarded as the least preferable factors that drive the respondents to attend the course. The results were supported by findings in a study on factors affecting university and course selection which was conducted on students in Central Punjab (Sabir et al. 2013). The study indicated that the most important determinants in choosing a particular course were university reputation, interest in the offered subject and employment prospectus. Similarly, James (2007) found that International Baccalaureate students in Finland and Portugal accounted enjoyment and interest of a particular subject and career requirements before selecting the course they want to attend (Fig. 2).

(C) Level of understanding of sustainable development

In order to shape an environmentally friendly society, environmental knowledge, awareness and behaviour must be inculcated through education and awareness training (Kaur 2017). In this study, it was evident that the level of understanding of sustainable development among respondents from the first to the second test has substantially improved after attending the course (Table 3). A similar finding was reported by Michelle et al. (2015) in a survey on the employees of The Hongkong and Shanghai Banking Corporation Limited (HSBC) (Hong Kong). HSBC has taken an initiative to foster a green corporate culture by providing its employees with nature-based training. The results of retrospective post- and then- test questionnaires indicated that the participating employees have gained knowledge and their values and behaviour towards environment have significantly evolved.

Table 3 Level of understanding of sustainable development

Item		Mean	Std. deviation
Level of understanding	First survey	4.22	1.617
	Second survey	7.32	1.305

Table 4 Level of understanding of the course contents

Item		Mean	Std. deviation
Level of understanding of the course contents	First survey	3.99	1.536
	Second survey	7.49	1.253

(D) **Level of understanding of the course contents**

The course content of WSU 101 was also scrutinised in this study. Based on the tabulated data (Table 4), the respondents' level of understanding of the course contents has significantly increased after undertaking the course.

(E) **Knowledge on the components of sustainability**

There are three key components or pillars to be concerned when deliberating about sustainability; economy, social and environment (Basiago 1999). Integration of these interrelated components will form a balanced and solid ground, hence founded the concept of sustainability. The survey gauged the respondents' knowledge of the three major components of sustainable development at the beginning (Fig. 3) and at end of the course (Fig. 4). Generally, the majority of respondents were well-comprehended of all three components of sustainability although at the beginning of the course most respondents (50%) chose the environmental component of sustainability. At the end of the study, the pie chart was noted to be almost equally distributed, hence consolidating the respondents' grasp of a balance between all components of sustainability.

(F) **Sustainability issues and challenges**

The opinions of respondents pertaining to sustainability were acquired. The results presented in Table 5 showed a varying pattern. Population and poverty item and agriculture item showed an increase from 8.2 to 11.4% and 8.5 to 12.6%, respectively. Meanwhile, at the beginning of the course, population and poverty item as well as agriculture item were selected the least by the respondents. After the course has ended, the number was however increased, signifying that the respondents were indeed recognised the two items are parts of the world sustainability issues and challenges. Additionally, issues like water, climate change and disaster risk management, and production and consumption showed a decrease from 16.8% to 14.1%, 16.3% to 12.4% and 10.3% to 8.7%, respectively, although these issues are among the top sustainability issues, nationally and internationally.

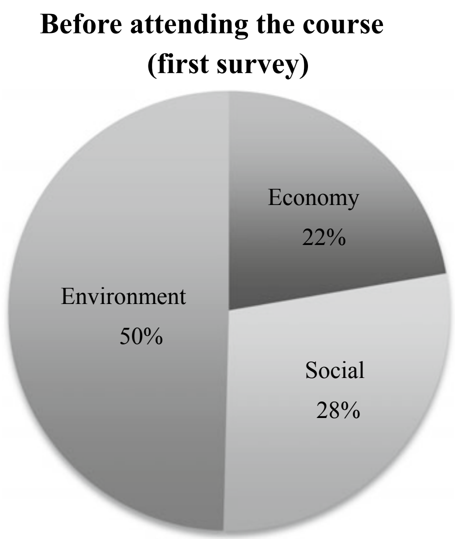

Fig. 3 Components of sustainability according to respondents in the beginning of the course

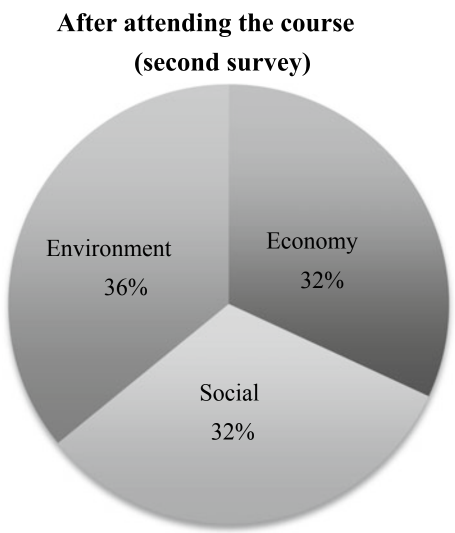

Fig. 4 Components of sustainability according to respondents at the end of the course

(G) **Sustainable lifestyles**

Based on the results in Table 6, activities such as recycling, volunteering in environmental conservation and the use of environmentally friendly products has respectively recorded percentage increases of 21.8, 13.5 and 19.3% in the second test. On the other hand, activities like carpool and sustainable consumption of energy and water were less selected in the second test. Both activities recorded a decrease in term of percentage from 24.5% to 20.9% and 38.7% to 24.5%, respectively.

Table 5 Sustainability issues and challenges

Item	First test (%)	Second test (%)
Water	16.8	14.1
Energy	13.8	14.0
Health	12.5	13.5
Agriculture	8.5	12.6
Biodiversity	13.6	13.3
Climate change and disaster risk management	16.3	12.4
Population and poverty	8.2	11.4
Production and consumption	10.3	8.7

Table 6 Sustainable lifestyles practiced by the respondents

Item	First test (%)	Second test (%)
Carpool	24.5	20.9
Recycling	18.2	21.8
Participate in environmental conservation volunteer activities	12.8	13.5
Energy and water consumption (in hostel, lab, class, home etc.)	38.7	24.5
Use of environmentally friendly products (electrical device, food container etc.)	5.9	19.3

4 Conclusion

The inception of WSU 101 as an elective curriculum is an evidence of USM's seriousness of sustainability development. The course was found effective to invoke awareness on the issues concerning sustainability besides very successful to proliferate the knowledge of students. These progress successively led to behavioural changes among students. The findings garnered from this study can act as a sound baseline data that will pave for a more detailed exploration and ultimately implementation of ESD worldwide. Nonetheless, more in-depth studies must be carried out in search of suitable pedagogical approaches or strategies that work better at increasing the effectiveness of similar courses. As pedagogical needs and cultures differ worldwide, further studies would enable the discovery of specific pedagogical techniques that effectively suit a particular geography, culture and socio-economy. Higher education institutions nationwide must adopt to start undertaking T&L programmes that gear toward sustainable development, as their role in creating a generation of sustainability conscious youth is imperative. Courses like WSU 101 are a great, cost-effective platform that could educate and create a ripple effect within the community.

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Mainstreaming Education for Sustainable Development in English as a Foreign Language: An Analysis of the Image-Text Interplay Found in EFL Textbooks in Japanese Higher Education

Joshua Jodoin and Jane Singer

Abstract The Sustainable Development Goals recognize climate action, sustainability, and quality education as critical issues, with Education for Sustainable Development regarded as a central approach for promoting the attitudes and behaviours needed to achieve the Sustainable Development Goals. Education for Sustainable Development efforts at the university level include mainstreaming environmental content in all curriculum, including in requisite courses like English as a Foreign Language at Japanese universities. Although environmental topics and themes are popular content for English textbooks, there has been little research examining whether this content is being used effectively to educate university students and promote environmental behavior. This paper presents an analysis of a corpus built from sample texts with environmental themes found in English as a Foreign Language textbooks commonly used at Japanese universities, employing codification and corpus analysis techniques. The research offers a novel approach to mapping image-text interplay within a corpus using the KPV-model (Scientific Knowledge, Social Practices, and Values). The results suggest that the image-text interplay found in the corpus often do little to further the attitudes, values, and practices considered central to effective Education for Sustainable Development and there appears to be little thematic interconnectedness between topics, images, and texts. The results also suggest that textbook creators are paying little regard to the inherent aims of including environmental content, either in terms of promoting Sustainable Development Goals or promoting ESD-linked sustainability competencies. To improve the efficacy of environmental content in English as a Foreign Language curriculum the authors introduce a holistic framework for English as a Foreign Language content creators.

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Keywords Education for sustainable development (ESD) · Sustainable development goals (SDGs) · English as a foreign language (EFL) · KPV-model

1 Introduction

The concept of "sustainability" has become ubiquitous in public debate, education, policy negotiation, and news. It has become clear, however, that promoting technologies and policies are not enough to deal with climate change and other sustainability issues such as poverty and gender inequality; efforts are required to educate citizens and facilitate change in sustainability attitudes and behavior, as has been recognized by educators and researchers involved in the field of Education for Sustainable Development (ESD). ESD is a value-laden field and, at its core, is tasked with identifying sustainability-related goals and working towards them in order to confront and solve environmental and developmental issues (McKeown 2002, pp. 13–14). ESD was first introduced by the World Commission on Environment and Development (1987), and it gained great traction among policymakers and the general public during the United Nation's (UN) Decade of ESD (DESD) from 2005 to 2014. Since the Decade's end, ESD has continued to expand its reach, and it is now embedded within the United Nation's agenda for achieving the Sustainable Development Goals, or SDGs. Of interest is SDG #4.7, which states, as its sub-goal, that:

> by 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship, and appreciation of cultural diversity and of culture's contribution to sustainable development (United Nations 2015, p. 17).

This goal calls upon educators and knowledge facilitators to mainstream sustainability and other ESD content into their lessons, teaching materials and institutions. Many universities in Japan and around the world are now including the SDGs in their operational and academic planning (Grierson and Hyland 2012; Azapagic et al. 2005; Barlett and Chase 2013; Barth et al. 2016; Barlett and Eisen 2002). However, other universities have faced tremendous challenges in integration of ESD across disciplines and faculties, in part because ESD needs a community of practitioners to be effective (Corcoran and Wals 2004; Stevenson 2006; Johnston 2013). Minster et al. (2013) provide an example of successful integration in an engineering program, due to the support of the wider engineering teaching community.

1.1 The Sustainable Development Goals

The SDGs represent a "universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity" (United Nations Development Programme 2018). Participation in the SDGs is an essential requirement of governing bodies and institutions around the world. Accordingly, universities, as repositories of knowledge and learning, can assume a leadership role in making the SDGs, and supporting concepts, a part of the fabric of higher education. This is a tremendous challenge and holistic approaches are necessary to improve faculty and administrative participation and engage relevant stake-holders in this shift towards sustainable universities (Alshuwaikait and Abubakar 2008; Disterheft et al. 2015; Ferrer-Balas et al. 2009). However, several barriers to change, such as conservatism, unwillingness to change, or lack of sustainable development information, have slowed the process of adoption at the university level (Lozano 2006, p. 791).

The seventeen SDGs have broad appeal and application, allowing them to link with a variety of disciplines in higher education and facilitating their willing adoption. Ultimately, the most effective approach is to integrate ESD in a wide variety of disciplines. However, as seen with the case study of English as a Foreign Language at the tertiary level in Japan, adoption of the SDGs and concepts like ESD is slow and requires greater understanding of their significance and institutionalized backing.

1.2 ESD in Japanese Higher Education

Japan's Ministry of Education, Culture, Sports, Science, and Technology (MEXT) regards EFL as well as ESD as an integral part of Japanese education. All public primary and secondary schools require that each grade's curriculum include a prescribed number of hours for "integrated education," which often includes ESD themes such as environmental sustainability and local cultural heritage, although implementation may vary by school. However, ESD in higher education is yet to be systematically addressed:

> ESD implementation in curricula or student-led initiatives at Japanese universities have lagged behind what can be found in primary and secondary schools and in universities in many other developed nations, but sustainability-linked research and green campus efforts are expanding (Singer and Nagata 2017, p. 28).

Awareness of ESD and SDGs appears to be expanding at universities but there remain some institutional barriers to effective implementation. For example, traditional faculty autonomy impedes attempts to implement ESD at the university level. Moreover, these barriers appear even before students enter university. For instance, MEXT has yet to identify SDG competencies or develop new ways of teaching and learning together with ESD curricula in primary and secondary education (UNESCO 2009b).

1.3 EFL in Japanese Higher Education

MEXT shows considerable enthusiasm for promoting English as a Foreign Language (EFL) education. English is a compulsory subject in primary and secondary as well as at most tertiary institutions (Chang 2011, pp. 197–198). Most Japanese university students are required to study English at university, although the quality and form of this education varies dramatically between institutions. The promotion of EFL in Japanese higher education can be seen as a means to foster students who can live and work abroad, students who are more linguistically competent in a globalizing workplace, and, more broadly, future citizens who can represent Japan in a globalizing world. To do this, Japanese universities rely heavily on EFL textbooks that are produced by major international publishers like Cengage, Oxford University Press, and Pearson Longman.

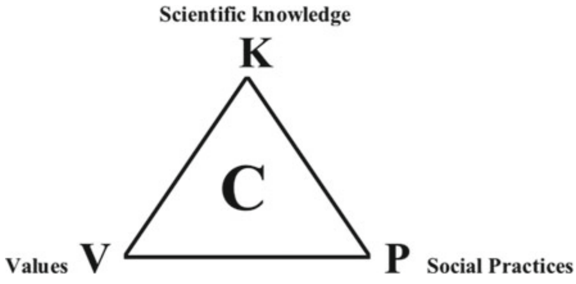
According to Caravita et al. (2008, p. 99), "Textbooks represent one of the pillars of formal education and they often represent the actual curriculum, since they may heavily influence the content, the approach, and the teaching style." EFL textbooks in Japanese higher education often serve as the basis for the course curriculum, with textbooks guiding all classroom activities. Furthermore, these textbooks determine the sequence of topics and the topics themselves. They also indirectly contribute to a students' world views, attitudes, and beliefs, and may convey values, either subtly or explicitly (Jones et al. 1999, pp. 354–355). They may be the only source of information a university student receives about environmental sustainability. Understanding how these topics are represented in EFL textbooks and the kinds of values, themes, and understandings presented are largely absent from current ESD literature. Therefore, as multimodal constructions of knowledge become the norm in education, the presentation of environmental imagery and text in EFL textbooks should be better understood.

Currently, the Japanese textbook market is saturated with textbooks that have adopted environmental themes and topics as a platform for teaching English. For instance, many English as a Foreign Language (EFL) textbooks used in Japanese higher education have sections or entire chapters dedicated to environmental topics like "sustainability" or "climate change." This presents an opportunity for textbook writers and curriculum developers to integrate promotion of ESD competencies and the knowledge, attitudes and behavior needed to achieve the SDGs.

1.4 Theoretical Approaches to Images and Text in Textbooks

Imagery plays a significant role in most learning contexts, whether in "image-text relations" (Unsworth 2006) or in multimodal constructions of knowledge (Kress 2003; Weninger and Kiss 2013). The construction of knowledge is achieved through the interplay of written language and imagery in contemporary writing, teaching, materials creation, and assessment (Guo and Feng 2015, p. 115). There is little dis-

Fig. 1 KVP model



pute that imagery is a powerful medium to convey ideas and to support writing in language teaching and education generally. Therefore, an analysis of the environmental imagery used in EFL textbooks can offer another way to evaluate a textbook's utility in promoting ESD.

Although there are many theoretical frameworks that can be used to understand the interplay between text and imagery in textbooks (Kress and van Leeuwen 2006; Halliday and Matthiesesen 2004), the didactics of the sciences (Astolfi et al. 1997) as used by Carvalho et al. (2008) will be adopted for this analysis. This science-based theoretical approach to understanding imagery is particularly useful for environmental studies because the theory has a strong natural science dimension and it is based on the KVP model (Clément 2006), which conceptualizes three poles (Fig. 1): Scientific knowledge (K), Values (V), and Social practices (P). Ultimately, ESD has the goal of shaping future citizen's behaviors so student knowledge about the environment (K), the values students place on the environment (V), and the influence of this knowledge and values (P) are important to understand.

In terms of Scientific Knowledge (K), for the purposes of this research images and their associated text will be analysed for their relevance to contemporary environmental science in terms of the facts and ideas presented. Values (V) are represented as the values, beliefs, ideologies, and opinions imbued in imagery and text interplay. In terms of ESD, specific values that are communicated in the sample texts and related to human-nature interactions are of particular interest. Social Practices (P) are created by the actors in tertiary education, such as the faculty, students, and administrators, as well as the textbook creators. Social Practices (P) could be representative of the messages, whether social or scientific, that are contained within the image-text interplay as intentioned by the actors associated with the text samples. The KVP model will be used as a tool for the analysis of image-text interplay as well as a basis for the four conceptions and codification used in the analysis.

This research used a mixed-method approach to examine the role that environmental topics play in EFL textbooks through an analysis of a 55,000-word corpus and the image-text interplay found within the corpus. Several techniques were used in the analysis of the corpus, including codification and corpus analysis. The research sought to create a general framework for incorporating ESD in tertiary EFL content based on a case study of Japanese textbook samples.

The following research questions were used to guide the research:

1. How can image-text interplay be understood by applying a KPV model to environmental content in EFL textbooks?
2. Is imagery found alongside environmental content in EFL textbooks contributing to the construction of knowledge and the formation of beliefs and values about the environment?
3. Do images presented alongside environmental content in EFL textbooks link with ESD values and competencies including behavioral transformation?
4. How can ESD and the SDGs be integrated more broadly into EFL curricula?

2 Methodology

A novel mixed-method approach was used in this research in order to develop a framework for ESD integration into the EFL classroom. A corpus was used as the primary research data. The corpus consists of environmental topics and themes found in EFL textbooks published after 2004. At the time of writing, the corpus is composed of over 55,000 words taken from 12 different publishers of EFL materials commonly used in Japanese higher education. The corpus, composed of over 30 sample texts, mainly consists of entire chapters found within an EFL textbook on themes ranging from "climate change" to "forests." The corpus also includes over 140 separate images that have been analysed for the purposes of this research. The sample texts range from low intermediate, or B1 on the Common European Framework of Reference for Languages (CEFR) (Council of Europe 2001), to advanced, or C1 on the CEFR. The sample texts include all instructions, picture headings, grammar points, titles, and vocabulary. Some of the textbooks were written specifically for Japanese students, but the majority are from major publishers like Cengage Learning and Oxford University Press that use region-specific rather than country-specific textbooks. In other words, many of these textbooks are published for a broad EFL or English as a Second Language (ESL) audience and are not intended to be culturally specific. Text and image data was gathered for analysis using two primary research methods: codification and corpus analysis. This paper will focus on the codification but uses some corpus analysis results when applicable.

2.1 Codification of Data from the Corpus

During the codification process, two primary tools were used: ATLAS.ti and Microsoft Excel. ATLAS.ti is a qualitative tool used to code texts and perform qualitative analysis of data. The software was used to code texts and images found within a corpus using a codification framework developed in Tables 1, 2 and 3. This data was then used to understand patterns, links, and associations in the corpus for further

Table 1 Sub-topics commonly found in education for sustainable development (ESD)

Sub-topics commonly found in education for sustainable development (ESD)	Explanation
Ecosystem and cycles (EC)	Comes from modern understandings in the field of ecology and is linked strongly to system dynamics
Biodiversity (BDY)	Central to understanding concepts of evolution, ecological management, inter and intra-species diversity and culture
Pollution (PO)	Relates to the presence or introduction of substances poisonous or harmful to an environment. Often closely related to human impact on the environment: associated with human values and beliefs
Use of resources (UoR)	Relates to resources used by humans, associated with human values and beliefs

Adapted from Caravita et al. (2008, pp. 108–109)

Table 2 The four conceptions with examples

The four conceptions	Examples
Complex versus linear systems	• Webs versus chains of ecological components • Presence versus absence of feedbacks, retroactions, cycles
Relationship of humans in respect to nature	• Emphasis on risks, catastrophes, problems versus balanced information about problems and about possible solutions • Humans as external sources of pressures, pollution destruction versus humans as legitimate agents and users of resources
Global versus local approach	• Focus only on local environments versus multiple environmental typologies • Locally focused view of resource management versus globally oriented view of resource distribution and management
Individual versus social responsibility	• Emphasis on change in individual behaviours versus emphasis on change in lifestyles at society level • Moral responsibility versus political responsibility

Taken from Caravita et al. (2008, pp. 109–111)

analysis. The second tool was Microsoft Excel, to keep track of the data and perform basic statistical analysis on the findings.

Several codes were developed based on the model of the BIOHEAD-Citizen Project (Carvalho et al. 2008) and this system was used to analyse the Scientific Knowledge (K), the Values (V), and the Social Practices (P) found in the sample

Table 3 Codification categories and code options

Codification category	Code options
Relationship of image to the text?	• Yes, direct • No, indirect • No association to the text (appears to be decorative)
Themes of sample texts	• Global warming/climate change • Pollution • Water • Shortage/drought • Deforestation • Ecotourism • Energy • Climate/weather changes • Population • Green technology • Forests • Water shortage • Endangered species • Life sciences • Earth science • Waste disposal • Road construction • Alternative energies • Transportation • Food • Saving the rainforest • Safari • Saving water and resources • Wind energy • Ecological footprint • Pollution
Target skill	• Reading • Writing • Listening • Speaking • Mixed (e.g. reading into speaking, listening into writing)
Learner level (CEFR)	• Basic user (A1)/beginner low • Basic user (A2)/beginner high • Independent user (B1)/intermediate low • Independent user (B2)/intermediate high • Proficient user (C1)/advanced low • Proficient user (C2)/advanced high

texts based on the KPV-model. More specifically, the sub-topics (Table 1) as well as the four conceptions (Table 2) were adapted from the BIOHEAD-Citizen Project (Carvalho et al. 2008) as well as from a subsequent paper by Caravita et al. (2008). These sub-topics and the four conceptions offer a useful tool to understand how ideas are presented in environmental texts and have been adapted for this research. The four sub-topics common to ESD are identified in Table 1.

The sub-topics in Table 1 can be codified and applied to imagery in the corpus. These sub-topics are useful to understand how imagery found in the corpus is being used in relation to ESD principles such as giving citizens a better scientific understanding of environmental problems and facilitating and encouraging greater awareness of these issues (McKeown 2002, pp. 8–9).

In addition to codifying the sub-topics, a set of four important conceptions are used and targeted in the image-text analysis. These conceptions are not only used by Caravita et al. (2008) and the BIOHEAD-Citizen Project, but also have been used in a variety of research since they were originally posited in relation to the New Environmental Paradigm (NEP) scale of indicators as defined by Dunlap and Van Liere (1978). The four conceptions are found in Table 2.

The four conceptions serve to show the way people integrate ESD aspects into their lives as well as present their worldviews (Caravita et al. 2008, p. 109). In terms of curriculum writers and content creators of textbooks, these conceptions can offer insight into the purpose for writing or using particular imagery. Furthermore, the four conceptions, as applied to imagery found in the corpus, offer a convenient simplification of worldviews espoused in the environmental themes and topics found in the corpus. Using the four conceptions to code imagery offers an insight into the Social Practices (P) as well as the Values (V) from the sample texts as used in the KVP-model.

Several other aspects of the corpus have been codified and mapped within the corpus such as the relationship of the image to the text, the themes of the sample texts, target skills and the learner level as related to the Common European Framework of Reference for Languages (CEFR) (Council of Europe 2001). These codes are found in Table 3.

2.2 Corpus Analysis

The programming language R and AntConc software (Anthony 2014) were used as the primary tools for the corpus analysis. R is used to perform very sophisticated quantitative analyses using downloaded packages. Specifically, “tm,” “SnowballCC,” “RColorBrewer,” “ggplot2,” “wordcloud,” “biclust,” “cluster,” “igraph,” “Rgraphvis,” and the “fpc” packages were used. AntConc was used for some basic word frequency and concordance analysis. For the purposes of this paper, the corpus analysis will only be referred to when applicable.

3 Results

The "Subtopics commonly found in ESD" were coded as outlined in Table 1. There were several sample texts that used two topics, such as a unit entitled "The Footprint of Fun," which was coded with both PO (pollution) and UoR (Use of Resources), as the unit dealt with the idea of humans creating pollution such as plastic waste and then talked about ways of recycling and composting. The results of this analysis are found below in Fig. 2.

The results from Fig. 2 show that Use of Resources (UoR) was by far the largest sub-topic found within the sample texts, accounting for 39% of the total. UoR appears to be a popular topic in EFL textbooks. Ecosystems and Cycles (EC) made up the second largest sub-topic, at 19%. The lowest frequency was for Pollution (PO), at 11%.

The "four conceptions" as outlined in Table 2 were coded to each image found in the corpus (Fig. 3). Many images were codified as embodying two conceptions.

The data in Fig. 3 revealed that most images were used to show the "Relationship of Humans in Respect to Nature" at 40%. A typical example of this kind of image is a chainsaw lying next to a cut down tree. Interestingly, 37% of the images found in the corpus did not seem to represent a conception at all. Only 3% of images showed the conception of "Complex versus Linear Systems."

The relationship of the image to the text was coded for each image found in the corpus by looking at the associated text as shown in Fig. 4. A coding system was designed to show three relationships between the text and image: directly related,

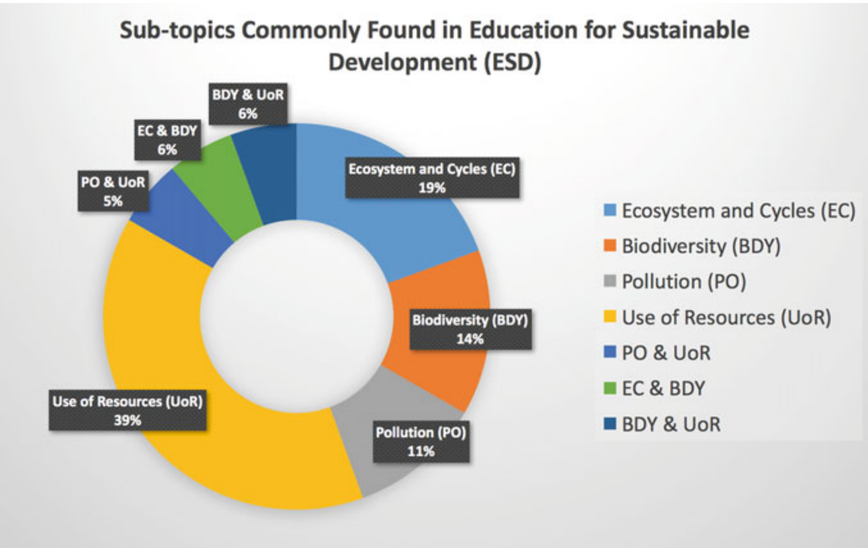


Fig. 2 Sub-topics commonly found in education for sustainable development (ESD)

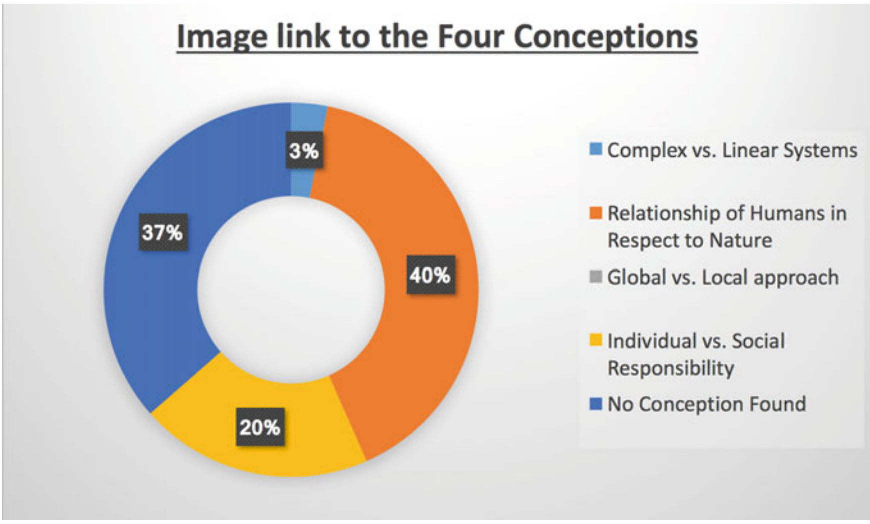


Fig. 3 Image link to the four conceptions used in education for sustainable development (ESD)

indirectly related, or seemingly decorative in purpose. An example of an image "directly related" to the text would show a lumberjack cutting down a forest and the associated text would talk about forests in terms of how wood can be used as a resource for human beings. An example of an image "indirectly related" to the text would show a sand dune in a desert and the associated text would be about climate change, but no direct links to desertification would be present in the text. An example of an image that "appears decorative in purpose" would be a student jumping in the air when the associated text would be about endangered animals.

As shown in Fig. 4, 58% of the imagery found in the corpus appears to be "directly related" to the associated text, 23% is "indirectly related" to the text and 19% appears to be "decorative in purpose."

The word cloud below in Fig. 5 represents the words most frequently found in the corpus and was produced by the programming language R using quantitative research methods. In general, words that are larger in size appear more often in the corpus text. The word "people," for instance, is the largest because it occurs in the corpus the most frequently at 240 times. Words in the word cloud appear in the text with a frequency of over 30 instances after the stopwords were removed. Stopwords are high frequency words found in the English language that have little meaning for this research, for instance, "the" and "and."

The word cloud in Fig. 5 offers a useful view of the types of environmental themes and topic represented by EFL textbooks. Based on a more detailed analysis of the corpus (Jodoin and Singer 2018), several words related to the environment arise from the corpus data, yet few environmental themes arise from the correlation between these words. For instance, the words "global" and "warming" as well as the words "endangered" and "animal" show strong correlation to each other and

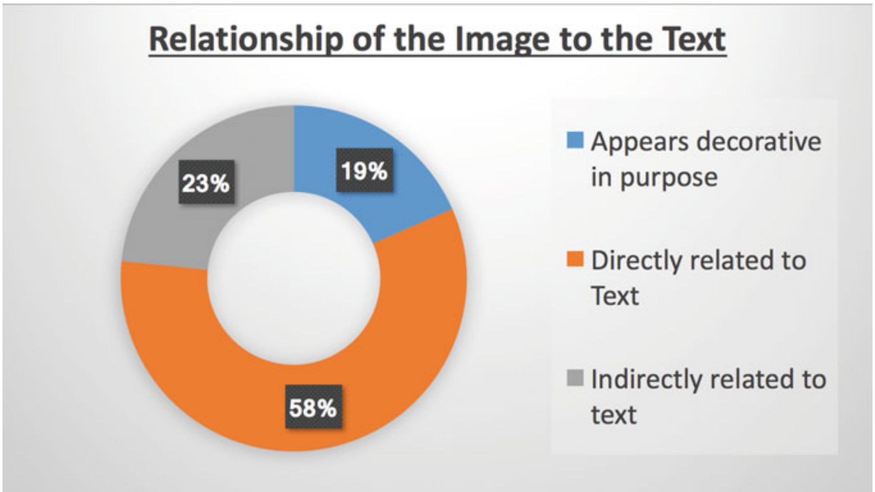


Fig. 4 Relationship of the image to the text

can be explained as being popular topics found in EFL sample texts of the corpus. Furthermore, few high frequency words, or head words, found in the corpus are value-laden (Fig. 5). An example of a value-laden word would be a word that challenges student values or attitudes such as "sustainable" or "respect." This lack of value-laden words indicates that the information provided in the sample texts is primarily informative in nature rather than being persuasive or challenging the attitudes and values of students.

4 Discussion

It should be noted that there is no mention in the forward or other parts of the textbooks used that the creators intended to integrate ESD or SDG content or approaches. The explicit objective of these textbooks is to improve students' English language skills. Nevertheless, there is a great scope for ESD integration as well as developing novel approaches for using the SDGs in the EFL classroom. Three main findings will be discussed below.

4.1 *Finding 1: Topics Rarely Challenge Social Practices (P) or Values (V)*

As indicated by Fig. 5, the corpus presents environmental topics but very few strong themes emerge from the corpus. In terms of the KPV model, the texts generally provide students with factual and accurate information (K) but do not seem to be addressing student values (V). This means that students studying these environmental topics from their EFL textbooks are gaining some scientific knowledge and

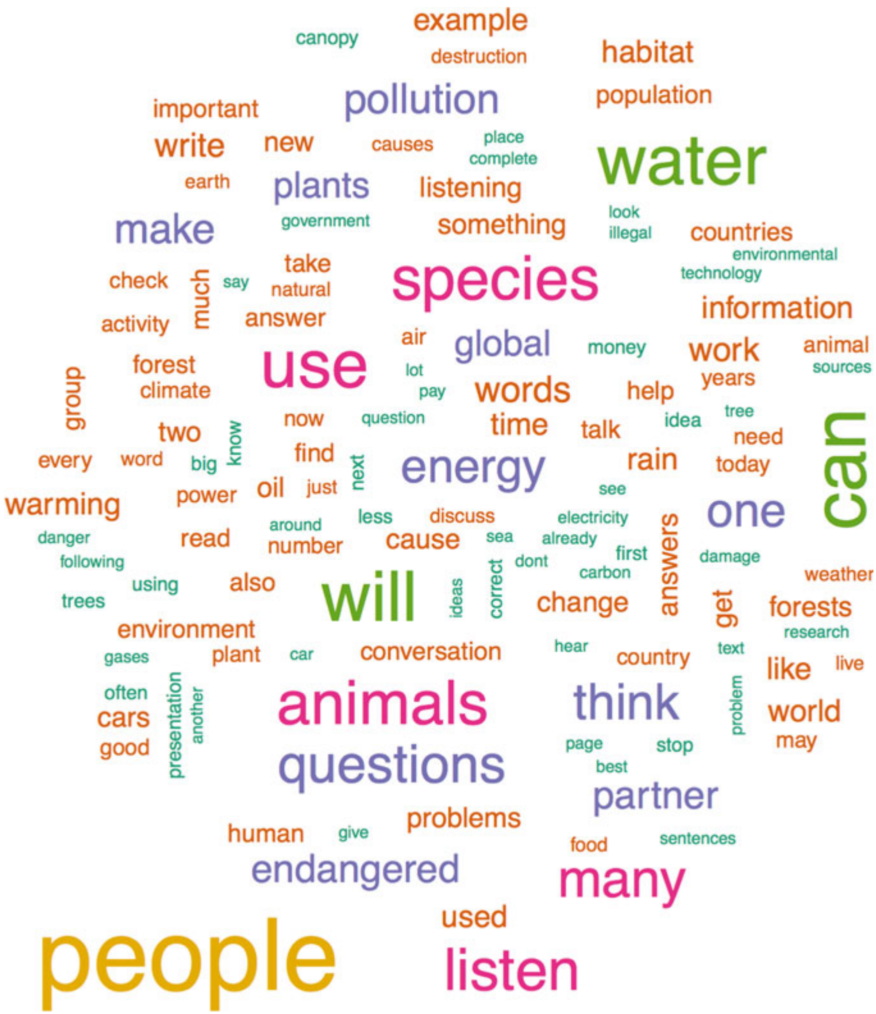
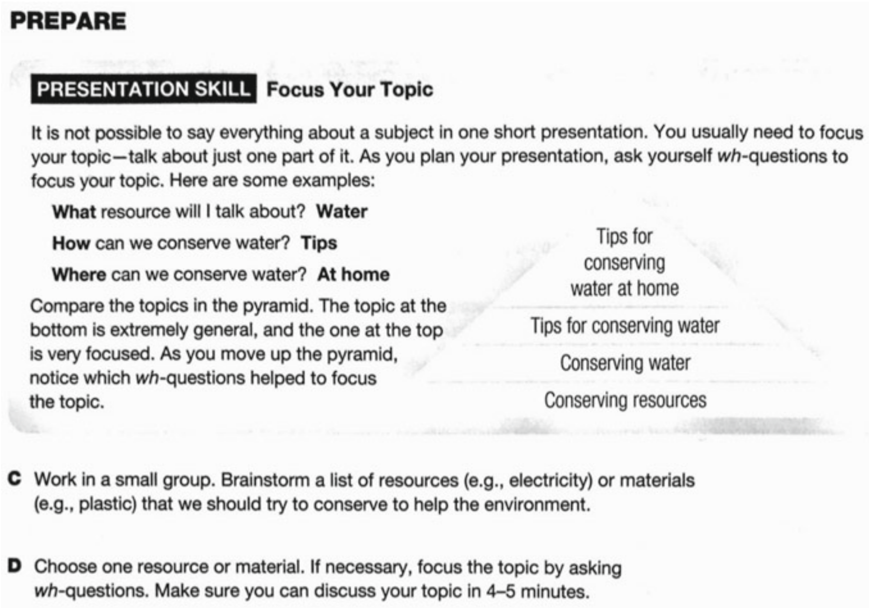


Fig. 5 Word cloud visualization of words found in the corpus with a frequency of over 30 instances



PREPARE

PRESENTATION SKILL **Focus Your Topic**

It is not possible to say everything about a subject in one short presentation. You usually need to focus your topic—talk about just one part of it. As you plan your presentation, ask yourself *wh*-questions to focus your topic. Here are some examples:

What resource will I talk about? **Water**

How can we conserve water? **Tips**

Where can we conserve water? **At home**

Compare the topics in the pyramid. The topic at the bottom is extremely general, and the one at the top is very focused. As you move up the pyramid, notice which *wh*-questions helped to focus the topic.

Tips for conserving water at home

Tips for conserving water

Conserving water

Conserving resources

C Work in a small group. Brainstorm a list of resources (e.g., electricity) or materials (e.g., plastic) that we should try to conserve to help the environment.

D Choose one resource or material. If necessary, focus the topic by asking *wh*-questions. Make sure you can discuss your topic in 4–5 minutes.

Fig. 6 Extension activity from a sample text entitled, “Small actions; Big results”

understanding. However, there are several areas, particularly as regards the P (Social Practice) and V (Values) elements, that can be improved to better promote ESD.

One way to do this is to have ideas and concepts recycled and integrated into subsequent lessons rather than teaching something in isolation from the rest of the topics in a textbook. To achieve effective ESD, Filho et al. (2014, p. 124) state that “there needs to be more of a focus on developing activities that challenge competencies like understanding complexity, as well as questioning systems, routines, and policies that show signs of being unsustainable.” In terms of EFL textbooks, a wider variety of topics could be developed to better challenge student values and beliefs (V), question the status quo (P), and show interconnectedness between topics. Figure 6 shows one way of presenting content that improves student competencies as taken from a sample text in the corpus (Baker and Blass 2017, p. 20).

The activity in Fig. 6 is a good example of an activity that challenges student values (V) and social practices (P) by giving the student an opportunity to present about conserving water and, at the same time, practicing EFL skills like presenting and using wh-questions. Unfortunately, examples like Fig. 6 were rare in the corpus sample texts.

Furthermore, Fig. 3 suggests that the choices made in adopting imagery for environmental topics used in EFL textbooks are not always challenging students’ conceptions of the world around them. For instance, the data shows that 37% of all images found do not connect to the four conceptions associated with ESD. This means that more than one in every three images found in the corpus are intended to decorate the page, make a loose association with text on a page, or are incorporated by writers or editors for some reason unknowable to the researchers. One suggestion is to have textbook creators think more carefully about the images they use and make an effort to connect these images directly with values (V) or social practices (P). A good example of this connection can be found in Table 4 Example 2.

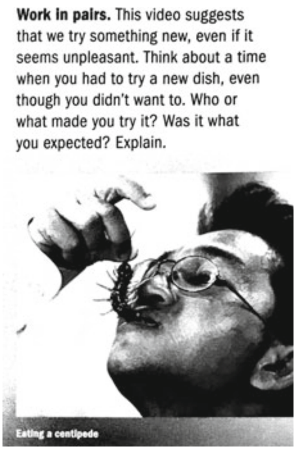
4.2 Finding 2: Lack of Synthesis Between Topics, Images, and Text

The analysis also found that the sub-topics used in EFL textbooks predominantly concern the Use of Resources (UoR) at the expense of other topics like Biodiversity (BDY) and Pollution (PO), as illustrated in Fig. 2. Particularly, the connection between what we use (UoR) and the waste that is produced (PO) is not strong within the sample texts. As Caravita et al. mention, "Pollution and the use of resources are crucial topics that particularly involve values and beliefs, and that are central in an education for a sustainable future" (2008, pp. 108–109). As such, the connection and overlap between topics around pollution (PO) and the use of resources (UoR) could be significantly strengthened within a lesson or textbook chapter as well as throughout the different chapters and topics within a single textbook.

Furthermore, the lack of topic synthesis and overlap could be considered problematic from the perspective of furthering sustainability learning, because sustainable development is a complex and dynamic topic that requires integrating and synthesizing many fields of study. In fact, one of the ways of integrating sustainable development into university programs is by holistically considering subject material. Filho notes the importance of "the holistic handling of sustainable development issues, integrating them with social and economic matters, as well as with biological and ecological issues, hence enhancing the quality of education provided to students as well as the quality of research" (2011, pp. 432–433).

ESD, when integrated into curricula, is a powerful tool for strengthening students' educational and research capabilities. Many examples of this kind can be found in the corpus. For instance, a unit called, "Small actions; Big results," discusses the costs associated with wasting water, and then introduces ways to recycle paper waste (Pollution, PO) in order to conserve water resources. Furthermore, the unit ends with activities, as seen in Fig. 6, which prompt students to recycle what they learned from the reading and challenges students to relate the topic to their lives. Overall, the unit succeeds in synthesizing concepts from two different subtopics (UoR and PO) as well as pushing students to think about their own values in terms of the conservation of resources. In terms of integrating sustainable development into the curriculum, the unit does an effective job of introducing important ESD concepts while teaching students English. In other words, EFL textbooks using environmental topics should consider integrating topics and showing environmental issues from several different points of view to holistically introduce sustainable development issues.

Table 4 Sample images found in the corpus with their associated codification

	Example 1	Example 2
Image		
Associated text explanation	This image is next to a chapter section entitled, "You shouldn't buy that stuff." Students are asked to listen to the conversations and write an appropriate phrase. The man sitting and thinking atop the earth shows a relationship of humans to nature but is not directly related to the associated text in a meaningful way. The image does not have any associated text or explanation	The image is found in a section where students watch a video about eating insects and answer questions about eating insects and its environmental impact. This follows a text about different techniques of food production and the importance of creating enough food for the human population. The image is directly related to the video and activities on the page. The image has associated text as seen above
Unit/chapter name	Pollution	Food matters
Code(s) assigned: Link to the four conceptions (Fig. 3)	Relationship of humans with respect to nature	Relationship of humans with respect to nature, individual versus social responsibility
Code(s) assigned: relationship of the image to the text (Fig. 4)	Appears decorative in purpose	Directly related to text

Another area that could be improved in EFL textbooks is the use of imagery associated with the four conceptions. For instance, "Complex versus linear systems" is only representative of 3% of the images found in the sample texts and there were no images referencing a "Global versus local approach." In terms of sustainable development, having a more balanced representation of important concepts throughout EFL textbooks would be beneficial. "Complex versus linear systems," for instance, can be used as an approach in discussing climate change. In Table 4, the Example 1 image-text interplay is limited. The image could be placed next to many kinds of texts without a deep or direct connection to the text itself. In terms of the KVP model, this appears to be an opportunity lost. The image as presented has almost no direct association with the activity itself, and is not offering any knowledge (K), challenging student values (V) or modeling social practices (P). On the other hand, Example 2 from Table 4 provides an example of an image and text interplay that directly challenges students on their values (V) and societal beliefs (P) concerning global food supplies. As one of the suggested activities in the textbook, students are asked to watch a video that challenges their ideas of what food is (V), to answer questions about the environmental impact of this choice of food (K or P), and then to discuss them based on the image in example 2 (V). Example 2 would appear to be a much more effective choice of image in relation to the text than example 1 as it challenges students' ideas about the world directly.

4.3 Finding 3: General Lack of Holistic Approaches to Sustainable Development

As mentioned earlier, EFL textbooks often use environmental topics in isolation from other topics and these topics tend to be subordinate to EFL goals. To reconcile the disparities between EFL as a discipline and the participatory and holistic approaches that ESD integration espouse, a framework (Fig. 7) is introduced.

Currently, EFL goals and objectives appear to overshadow choices in textbooks, and the content and topics seem to be regarded as somewhat incidental. In this framework, however, EFL content and language teaching content are given more balanced consideration in the creation of content for EFL classrooms as the foundational corners of the triangle. Based on more participatory and holistic approaches to integrating the SDGs into higher education, ESD can be used as a bridge to furthering the kinds of changes that are desirable in terms of student knowledge, values, and practices. As the SDGs provide a diversity of branching topics, the SDGs can inform the language teaching content of EFL classes at a foundational level.

In applying the framework, EFL content creators would need to understand how to provide the language skills common to EFL curricula while using topics and content informed by the SDGs. A good example of this is creating a lesson about water use in Myanmar's dry zone and linking this to SDG #13 on Climate Action. The content creator would then create EFL materials that not only teach English through using

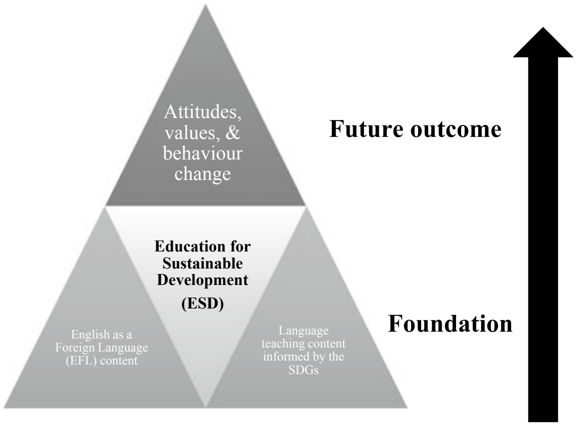


Fig. 7 Framework for ESD integration into the EFL classroom as a process

relevant topics from the SDGs, but also challenge student values and attitudes about the topic through appropriate image-text interplay and ESD best practice. Ideally, units and lessons are scaffolded in such a way that EFL concepts and unit topics are interconnected and build upon each other, giving students a holistic understanding of the content while they learn English.

This kind of framework can not only be used to help inform EFL materials and curricula within Japan but may be more broadly applicable as English language education continues to expand globally. Additionally, this proposed framework adds value to the field of EFL by making content more purposeful and integrated and contributes to training students "to deal with change, complexity, controversy, and uncertainty" (UNESCO 2012, p. 65) to achieve a more sustainable future.

4.4 Limitations

Firstly, a 55,000-word corpus is a good size considering the specific area of study: environmental topics within EFL textbooks after 2004. However, a general rule in corpus linguistics is that the bigger and more representative the sample size, the better. Secondly, the Framework (Fig. 7) is probably applicable to intermediate or above learners of English; otherwise many of the SDG topics and discussions may be inaccessible. Lastly, the novel approach to codification taken in this research can be easily applied to other contexts but the system of codification will need to be adjusted depending on the context and the scope of the research.

4.5 Future Research

The corpus will continue to grow as more sample texts are transcribed, coded, and analyzed, with the hope that the results can offer better insight for EFL content writers using environmental content. As mentioned in the discussion, it is often not clear why images were chosen for the textbooks, so collecting data from publishers as well as content creators would be a useful next step to understand the motivations behind content choice. Lastly, lessons learned from the analysis of the corpus could benefit future materials development, which could then be utilized and studied with university students as a living laboratory. At present, there is very little research about how environmental content used in EFL materials could be improved or how this content impacts university students in Japan and other countries.

5 Conclusion

Research on environmental content used in EFL is rather limited so this research initiated investigation aimed at identifying more effective approaches that will improve ESD knowledge, values, and social practices in this field. Using a corpus built from environmental content found in EFL, the image-text interplay was analysed and assessed for usefulness in promoting ESD concepts. The results suggest that the image-text interplay found in the sample texts of the corpus often do little to further attitudes, values, and practices inherent in ESD. Furthermore, there appears to be little interconnectedness between topics, images, and texts. Lastly, there appears to be a clear gap between the decisions that textbook creators make and what the SDGs promote in mainstreaming ESD, so more holistic approaches are recommended. Although EFL is primarily concerned with increasing English ability rather than increasing ESD competencies, the discipline would benefit tremendously from exploring how to mainstream ESD and use the SDGs as a rich source for content and topic ideas.

As the findings suggest, a more holistic framework to mainstreaming ESD (Fig. 7) is possible not only for Japanese higher education but as a model for more broadly applying ESD principles in English language teaching. Moreover, as many textbooks already feature helpful, scientifically accurate environmental content and educators are increasingly aware of the importance of the SDGs, there should be interest in improving students' understanding of sustainable development. Clear steps can be taken to improve the way that images and environmental content are presented in EFL textbooks to further ESD outcomes as well as advance the SDG agenda.

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Education for Sustainable Development: The STEM Approach in Universiti Sains Malaysia

Su Yean Teh and Hock Lye Koh

Abstract The appointment of Universiti Sains Malaysia as a Regional Centre of Expertise on Education for Sustainable Development by UNESCO in 2005 provided the incentives to spearhead several in-campus Education for Sustainable Development programs. The School of Mathematical Sciences, which has been actively pursuing education and research towards sustainable development goals since 1990s, has developed outreach, academic and research programs to promote Sustainable Development Goals, at local and global levels. This paper summarizes such research programs that develop relevant skills and competences in quantitative methodology for enhancing sustainable management of storm water, air quality and water quality in campus and beyond. Also presented is a recent initiative in unifying science, technology, engineering and mathematics for analysing the adverse impact of climate change on coastal groundwater and vegetation. This paper serves as a demonstration of how quantitative methodology can address local and global environmental issues and support implementation of SDGs in universities and beyond.

Keywords Water · Climate change · TUNA · MANTRA

1 Introduction: Education for Sustainable Development (ESD)

Since the publication of the Brundtland Commission Report on Our Common Future (WCED 1987), much enthusiasm has been devoted to the concept and implementation of sustainable development (SD), but with little discernible evidence of achieve-

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ment. To promote sustainable development goals (SDGs), UNESCO sponsors the program of Education for Sustainable Development (ESD), covering a broad range of goals, from natural resources to poverty reduction. Recognizing that education is an indispensable prerequisite for achieving sustainable development, the United Nations (UN) initiated the Decade of Education for Sustainable Development (DESD) 2005–2014. Concerned over the content, quality and purpose of education, DESD challenges all forms of educational provisions to adopt concept, design, approaches and practices that foster the values of sustainable development (UNESCO 2016). DESD highlights areas of action for education and promotes integrating key sustainable development issues into teaching and learning curriculum and pedagogy. These key issues include climate change, poverty reduction, disaster risk reduction, biodiversity preservation, and sustainable consumption. On climate change, education provides basic knowledge on chronic hazards such as floods, droughts, increased temperatures, persistent epidemics and others and on how these hazards might affect economic activities, social justice, poverty reduction and performance in schools. ESD contributes to sustainable development by promoting personal, societal, economic, cultural and political changes via specific cognitive, socio-emotional and behavioural outcomes that enable individuals to deal with the challenges of SDGs. The three principle dimensions (economic viability, social justice, environmental sustainability) of sustainability are integrated with each other as they are interdependent and mutually reinforcing. Economic growth must proceed with the environment and ecosystems preserved, with the people's health and education enhanced and with equitable distribution of wealth and prosperity promoted. ESD aims to integrate relevant skills and competences in science and technology with other knowledge, attitudes and social-cultural beliefs to achieve a holistic theme.

In the Czech Republic, lack of meaningful and substantive public discussion on what constitutes SDGs was identified as an obstacle to deep transformation of the educational system and its reorientation towards ESD (Dlouha and Pospisilova 2018) and is a major hindrance to a successful implementation of SDGs worldwide. This highlights the importance of a sustainability framework that orients scientific and practical effort towards a negotiated vision of the future which is not a simple extrapolation of the present state. The relevant skills and competences, rather than pure knowledge per se, have become the priority educational goals in ESD (Jacobi et al. 2016). The role of competences has been duly recognized in supporting and empowering educators to fulfil their potentials and those of their students (UNECE 2011, 2016), and hence in contributing to bottom-up driven curriculum changes towards sustainability. Discussion and debate on the ESD competences are intensely conducted within the context of higher education in some but not all countries (Lambrechts et al. 2013; Rieckmann 2012; Wiek et al. 2011). Fine examples of good practice in 53 higher education programs from 33 countries across Europe have been reported in Mula et al. (2017), UE4SD (2014) and UE4SD (2015). Competence oriented approaches in teaching and learning were consequently identified as one of the critical factors in the successful transformation towards ESD (Dlouha et al. 2017). TheGoals.org is a joint venture between the United Nations Sustainable Development Solutions Network and the International Foundation for the Young Masters

Programme. Its purpose is to support the implementation of the SDGs by communicating them to young people across the globe and by engaging concrete actions to fulfil the SDGs. It offers free, high quality education via a mobile first platform with content closely tied to the SDGs, focussing on mobilizing youths' local actions as solutions to global challenges. It collects and showcases local challenges, solutions and inspirational stories, the effects of which can serve as feedback to and enhance advocacy for the international development goals (Chin and Jacobsson 2016).

This paper will focus on relevant quantitative skills and competences, based upon science and technology, in promoting SDGs, premise on the confidence that our common cultural heritage would foster meaningful dialogue to embrace inclusiveness of all knowledge and competence domains (Hanley 2005). This approach is consistent with the program undertaken by the School of Mathematical Sciences (SMS) in integrating sound scientific education in relevant ICT and mathematical skills and competences with other domains and social-cultural values. This paper aims to demonstrate the application of quantitative methodology in support of sustainable management of the environment, covering both the local, national and global scales, focusing on the water segment. Sustainable management of water and sanitation for all (SDG 6) is central to the attainment of virtually all other SDGs (Kadi 2016), particularly SDG 1 (No poverty), 2 (No hunger), 3 (Good health), 14 (life below water) and 15 (life on land). Globally, water is one of the leading drivers of economic development but is also a potential source of contention and conflict (UNEP 2008). The patterns of inequity, variability, extremity and unreliability in water resources and their allocations are deteriorating in many regions because of the impacts of climate change (UN DESA 2015; WWAP 2015). High population growth, rapid urbanization and industrialization, coupled with increasing material demand from affluent lifestyle, have increased demand for many natural resources, including food and water. The intensified and unsustainable use of these resources will have serious implications for the environment and long-term security of many sectors. Technological innovations that enable more food to be produced with fewer resources, producing more crop per drop of resources utilized, will be critical to addressing the growing challenges of resource constraints and long-term depletion. With fast growing population and economic development, Asian and African countries face mounting challenges in meeting the growing demand for food, water and other resources. How a specific university like Universiti Sains Malaysia (USM) has contributed to innovative approaches in education and research on SD in addressing these mounting environmental pressures is the focus of this paper.

2 Method: Sustainable Management of USM Campus Environment

In support of DESD, USM initiated the concept and practice of a "University in a Garden", in which human coexists with the entire ecosystem in harmony, consistent with the aspirations of the UN DESD (2005–2014). A key aspiration is to promote education that ensures that the fulfilment of the needs of today would not compromise the access of the future generations to the gifts and bounty of nature. Under the University in a Garden Program, as a part of ESD, USM embarked on several projects to enhance campus wide environment and ecosystem. This section provides a narrative on several in-campus case studies to improve the management of air quality, water quality and storm water. The two study sites selected for these projects are (i) the compound surrounding the School of Chemical Sciences (SCS) adjacent to the New Science Complex (NSC) and (ii) the flood retention lake known as Tasik Harapan (TH). In these research programs led by the SMS, quantitative methodology in the form of simple mathematics or robust simulation models was used to assess the current campus environment and if deemed necessary, find sustainable solutions to improve the environment. Some of the quantitative approaches used for these in-campus studies were subsequently extended to areas beyond the campus. Specifically, the methodology used for evaluating storm water management in USM campus was extended for simulation of flood management options in the Penang Island. Finally, a recent initiative for assessing and mitigating the adverse impact of climate change on coastal groundwater and vegetation is then presented. Involving many parties working towards common SDGs in the campus, these projects served as vivid examples of good research in promoting ESD and SDGs in university. Indeed, the knowledge and skills acquired empower USM scientists and graduate students to share their expertise in several environmental studies nationally and internationally, serving to empower education under ESD.

2.1 Air Environment

The NSC was completed in early 2000 to provide offices for the SMS and the School of Computer Sciences (SCPS). The NSC building is located near to the SCS (Fig. 1a), which has numerous exhaust chimneys (Fig. 1b) for the release of chemicals used in the SCS. A research project was conducted to evaluate the potential health hazards of fume emissions from the SCS on the NSC, in view of the proximity between SCS and NSC. The emitted fumes could be removed before leaving the chimneys by means of scrubbers that would demand hefty capital investment and that would also require significant quantity of water for its proper operation. The use of scrubbers would have transferred an air pollution problem to one associated with water pollution and water consumption, a typical trade-off often encountered in achieving SDGs. After considerable debate, it was deemed desirable to avoid the scrubbers if it can be confirmed by mathematical modelling study that this would not lead to air pollution harmful to the campus community. Hence, modelling analysis was performed by means of the air transport model ISC-AERMOD View (Tesse et al. 2000), developed by the United States Environmental Protection Agency (USEPA), to evaluate the potential hazard due to the fumes emissions from the SCS. As NSC and SCS are close to each other, building wake effects must be carefully considered, as it may significantly increase

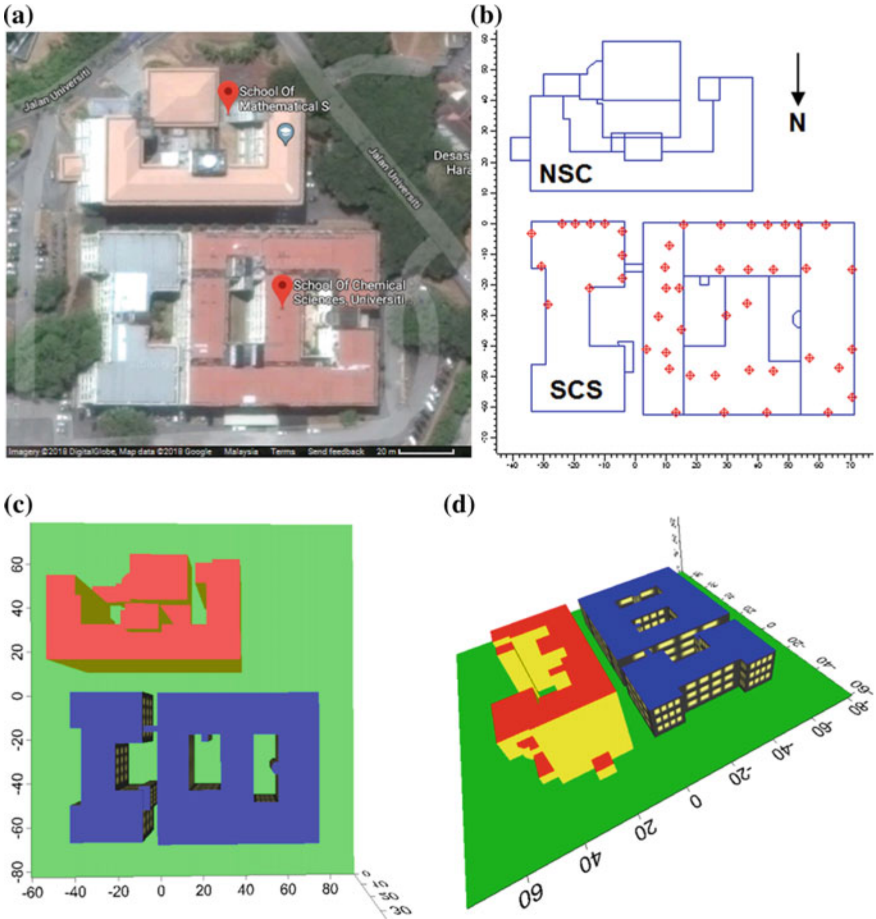


Fig. 1 **a** Location of NSC relative to SCS, **b** Chimneys (red dots) at the top of SCS buildings, **c** 2D and **d** 3D visualization of the buildings in the model

the concentration of the emitted chemicals. Taking building downwash (Fig. 1c, d) into effect, model simulations indicate that the air pollution levels (Fig. 2) are well within the international safety limits, and are unlikely to pose health hazards for occupants in the surrounding buildings and in the campus. A concomitant eight-hour field-lab survey conducted over several days on personals working in the affected buildings confirmed the results of the simulation study that the fume emissions are unlikely to pose health hazards. Thus, the collaborative effort between mathematics (model simulations) and chemistry (field test and measurements) reassured the campus community of good air environment in the vicinity of NSC and SCS even without the installation of expensive scrubbers. This decision had avoided the transfer of air pollution problem to the problem of water pollution and water consumption.

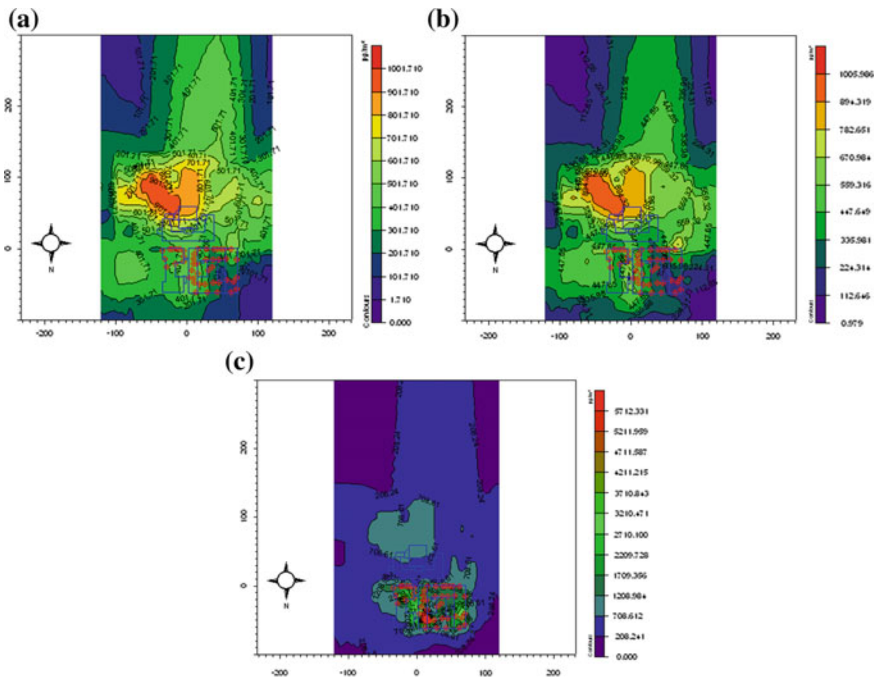


Fig. 2 Dichloromethane concentrations at **a** 0 m, **b** 15 m and **c** 25 m above ground level

2.2 Water Environment

The SDG 6: clean water and sanitation calls for sustainable management of water resources, including both surface and sub-surface water. Hence, a main interest in ESD within the USM campus is directed to the sustainable management of water resources, in order to maintain and enhance their ecological, environmental and hydrological functional integrity (ASCE 1998; UNESCO 1999). Getting more value from limited resources and incurring less consumption in order to conserve these resources is essential in attaining water security (Loucks 2000). With limited water availability worldwide, it is crucial to minimize the risk to fragile water resources systems and to develop approaches that could reduce the vulnerability of the ecosystems. The theme of the International Hydrological Program Sixth Phase IHP-VI (2002–2007) seeks to focus on sustaining water security via the theme "Water Interactions: Systems at Risk and Social Challenges". The management of water resources can be aided by modern ICT, including ICT-based simulation models, that can be useful in exploring ideas, in testing various assumptions, in identifying possible trade-offs, in understanding the output of system analysis, and in contributing to decision-making debate (Loucks 2000). The ESD project on sustainable management of water resources developed in USM seeks to achieve this aspiration.

Sustainable management of a small lake Tasik Harapan (TH) within campus provides an example of ESD research activity. A small lake of about 1.5 acres with an averaged depth of 1.0–1.5 m, TH was constructed in 1990 to reduce the frequency and intensity of flood in USM by holding the excess surface runoff for temporary storage in the pond after a heavy rain. Since then, TH has been observed to exhibit signs of eutrophication with high algae content and wild diurnal fluctuations of dissolved oxygen (Mansor et al. 2004; Teh et al. 2008). To advance the goals of ESD, the authors initiated two water-related research projects for developing and sharing expertise on: (a) analysing the effectiveness of TH as a flood retention pond and (b) assessing the status of eutrophication in TH, aiming to provide mitigation measures for controlling eutrophication. The expertise and social capitals acquired in these ESD projects were subsequently shared with other water-related research projects nationally and internationally. The following sections will present these two water-related research related to (a) storm water management and (b) water quality management.

2.2.1 Storm Water Management

Since its inception in the early 1970s, USM has been gradually converted from a former army barrack into a modern campus with paved roads, concrete buildings and lecture halls, surrounded by captivating and enchanting greenery, an exquisite example of a university in a garden. However, by 1990 it was realized that this conversion from a rural to an urban setting has caused a substantial increase in surface runoff, resulting in occasional flooding in the campus. To overcome flooding, the flood retention lake TH was constructed to hold excess runoff after a heavy rain for temporary storage to reduce the frequency and intensity of flooding. This study examined the adequacy of this retention lake as a flood mitigation measure, by means of flood management models. One model used is the WIN TR-55 (USDA NCRS 2009), developed by the Natural Resources Conservation Service (NCRS) of the United States Department of Agriculture (USDA). The second model is SWMM (Rossman 2015), developed by the USEPA. Any ESD project should begin with a methodology that is simple to use and is readily applicable to other sites and universities. For this purpose, a simple hydrological model WIN TR-55 is chosen to examine the adequacy of TH as a flood retention lake for the campus of about 200 acres. WIN TR-55 is appropriate for TH basin (200 acres) flood simulation as it is developed to assist in the design and construction of flood retention ponds for *small* urban basins of a few hundred acres or less. However, to extend application to flood analysis for *large* basins such as the Sg Pinang Basin (51 km^2 equivalent to 12,600 acres) in Penang, an advanced flood simulation model such as SWMM is also chosen to complement the capability of WIN TR-55. SWMM is an enhanced physically-based hydraulic flood management model developed to provide detailed and enhanced analysis of storm water routing over large basins.

A basic universal concept in flood management is to retain excess runoff on site (ASCE 1975). For this purpose, the hydrological model WIN TR-55 is chosen to estimate the retention volume required to store excess runoff on-site. Simulations indicated that TH has the capacity to retain excess runoff on-site only for rain events of low return periods of less than 2 years. Detailed analysis by WIN TR-55 concludes that the retention storage volume required to hold excess runoff for longer return periods of 5–10 years must be increased by two or three times. An advanced flood routing model SWMM is chosen for two purposes: (a) to extend flood simulation application to larger flood basins and (b) to provide detail information and flood scenarios within the campus for fine-tuning of mitigation measures. SWMM simulation shows that TH can reduce flooding in downstream river Sg Harapan under a rain of 2-year return period. However, under a rain with longer return periods, the lake's retention capacity will be insufficient. High runoffs did cause severe flooding in May 2011 and in Nov 2017. Excess off-site runoff originating from areas outside of USM campus contributed significantly to the flood volume, thus aggravating the frequency and intensity of flooding within the campus. Further, this off-site runoff contains high loads of nutrients and faecal coliforms originating from the adjacent neighbourhoods, contributing significant pollutant loads into TH. It is therefore essential to eliminate this external input of runoffs and sewage flows from entering TH, consistent with the basic principles of SDG 6: Clean water and sanitation. This option is currently under consideration.

2.2.2 Water Quality Management

Over the years since its construction, TH has steadily accumulated nutrients such as phosphorus P and nitrogen N, particularly in the sediments, causing the lake to become eutrophic with high algae contents and wild fluctuations of dissolved oxygen (DO) level over the diurnal cycle (Mansor et al. 2004; Teh et al. 2008). As part of ESD, a rehabilitation effort was initiated to clean up TH to a state suitable for recreational purposes. Monitoring and modelling of lake is conducted for understanding the dynamics of eutrophication, and for planning and implementing effective mitigation measures (Charumas 2004; Yacobi and Schlichter 2004). The E2Algae or TUNA model was therefore developed to analyse the DO-algae dynamics in the lake. Simulations were performed to investigate proposed rehabilitation options such as mechanical aeration and dredging of sediments. Simulation results indicate that mechanical aeration will not solve the eutrophication problem in TH (Fig. 3). Mechanical aeration during daytime proved to be futile, as the lake is already DO supersaturated during daytime. Data collected and model simulations performed indicate that the main culprit is the high phosphorus and high algae concentrations (chlorophyll a of 330 μg L^{-1}) in the lake, both of which will not be removed nor reduced by aerators. It may be concluded that mechanical aeration will not help much in the case of TH. Aerators may help to increase DO levels in aquaculture ponds due to the presence of high BOD.

A subsequent attempt was made beginning August 2010 to use mudball and effective microorganism (EM) to improve the water quality in TH, with undocumented success (Asha et al. 2010). The comparison of the data before (2004) and after (2011)

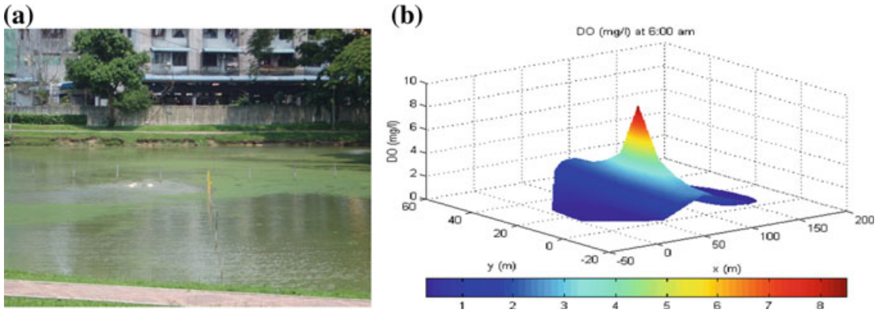


Fig. 3 **a** Observed algae dispersion with aerator and **b** simulated DO in Tasik Harapan with mechanical aeration

the continuous release of EM solution demonstrated no improvement in water quality (Fig. 4). The deep green color of TH after EM treatments confirmed high algae levels. It is obvious that mechanical aeration and EM treatment are non-solutions to eutrophication. Indeed, it was reported that after EM-mudball treatments of up to 1 g L^{-1}, the chl a concentration increased within 4 weeks from ≈120 to over 300 μg L^{-1} (Lürling et al. 2010). In another experiment, chl a concentration was significantly higher in EM-mudball treatments (52 μg L^{-1}) than in control samples (20 μg L^{-1}). Further, high amount of clay may induce subsequent high turbidity of the water. In short, EM is not effective in preventing cyanobacterial proliferation nor in terminating algae blooms because they neither permanently bind to nor remove phosphorus from eutrophicated systems, and because they have no inhibiting effect on cyanobacteria activity. They could even be an extra source of nutrients to further aggravate eutrophication (Lürling et al. 2010). Also deemed questionable in controlling eutrophication are golden algae, plant extracts and ultrasound (Lürling et al. 2016). The lesson learned from this ESD research projects provide the firm scientific foundations for controlling eutrophication.

Therefore, other viable alternatives such as removal of sediment from the lake bottom deserve more careful study. To effectively combat eutrophication, the sediments containing nutrients must be removed periodically, as otherwise these nutrients stored in the sediments will leach out and diffuse into the water column, inducing strong photosynthesis, promoting vigorous algae growth and reducing DO levels at night to critically low levels. Sediment may also contain high levels of BOD that may exert oxygen demand on the water column, particularly in shallow water body (Koh et al. 1995; Suomela et al. 2005). Secondly, TH contains high levels of nutrients because the lake receives regular sewage input from sources outside USM after a heavy rain. These sources of sewage inflow must be removed. Thirdly, TH is a stagnant lake, having virtually no flow under normal conditions, except floodwater overflow that enters the lake after a heavy rain. This stagnant condition promotes the accumulation of pollutants and nutrients in the sediment layers. A condition of regular flow should therefore be maintained for TH to constantly flush out the pollutants and nutrients that are inevitably introduced into the lake from sullage and sewage flow originating

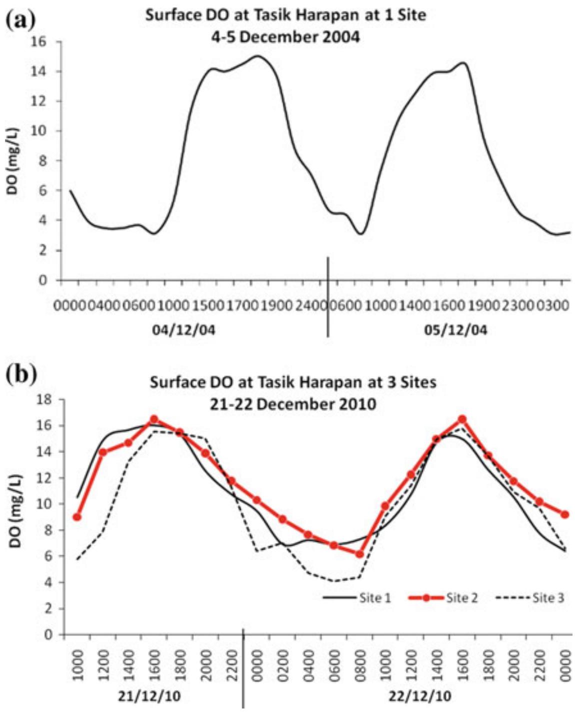


Fig. 4 Surface DO measured at Tasik Harapan **a** at one site between 4 and 5 December 2004 and **b** at three sites between 21 and 22 December 2010

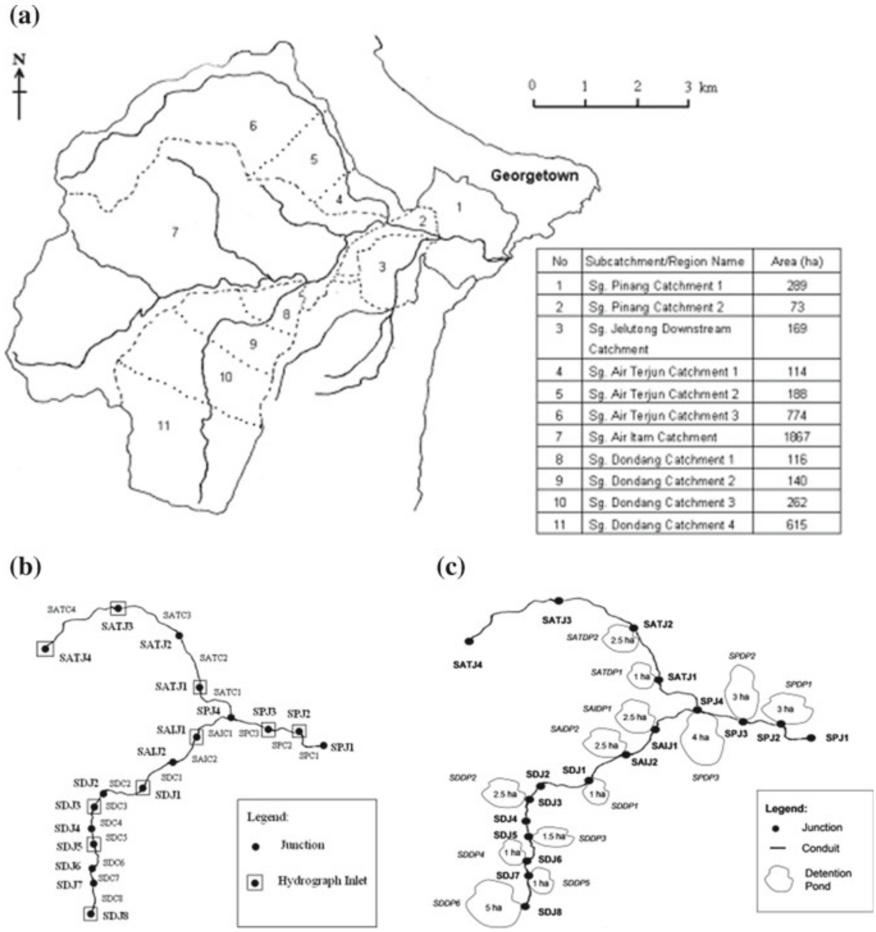
from outside the campus. A flowing river is a living river; a stagnant lake is a dead lake. To maintain mass balance of water in the lake, additional water sources need to be identified, while the water in the lake needs to be removed regularly. The removed lake water can be used for watering non-food plants in the campus. Rainwater should be harvested and stored within the campus to provide additional sources of water to be added to TH on a continuous basis. This idea of harnessing rainwater has been actively promoted and used in various countries (Han et al. 2004; Furumai 2008; Thomas et al. 2014) but its implementation in Malaysia is limited due to various challenges in environmental, policy, economic, social and technical aspects (Lee et al. 2016). Appointed as a Regional Center of Expertise (RCE) by the UNESCO under the program of Decade of Education in Sustainable Development, USM has the aspiration to provide leadership example in this area of sustainable utilization of water. This case study may then be extended to the state of Penang and other states in Malaysia to promote and practice sustainable development as a living example.

3 Flood Simulation for Sg Pinang

Frequent severe floods will have negative impacts on economic productivity, social equity and political stability, threatening many SDGs. Warming climates with associated SLR and intensified rain events will increase the frequency and intensity of floods in coastal regions such as Penang. SDG 13 calls for climate actions that mandate taking appropriate measures to mitigate flood damage and to protect the poorer sectors. It is anticipated that Malaysia will face various degree of SLR and extreme rainfalls (NAHRIM 2010). The recent extreme flood that affected 80% of Penang in November 2017 is a wake-up call for climate action. To relate the sustainable management of storm water at state level, the modelling methodology developed for storm water management in USM campus has been extended for Penang Island. The 51 km^2 Sg Pinang catchment (Fig. 5a) is divided into 11 hydrological subcatchments (further subdivided into 18 computational sub-segments). The SWMM modelling setup involving the links and junctions is shown in Fig. 5b.

Model simulation results indicate that flooding will be intensified by SLR and high tidal levels, particularly during extreme spring tides accompanied by high rainfalls. With SLR, a more severe flooding in the future is to be expected for Penang. Ecological soft engineering measures such as flood retention ponds constructed along flood prone areas to reduce flooding are preferred as they will serve two main functions: (a) reduce frequency and intensity of floods and (b) increase ecological services. The design and construction of flood retention ponds along the flood prone Sg Pinang basin can be assisted by numerical flood simulations, given the anticipated SLR and increase in precipitation induced by global warming. To mitigate the severity of flooding along Sg Pinang, a provision of 13 retention ponds, distributed over 13 locations, with a total volume of 30 ha-m is proposed (Fig. 5c). Distributing the retention ponds over a wide area is appropriate for sharing privileges and responsibility, as suggested by Åstebøl et al. (2004), and is consistent with the overall aspirations of SDGs. Where Sg Pinang begins, near the confluence between Sg Air Hitam and Sg Air Terjun (SPJ4 in Fig. 5), provision of retention ponds with a total volume of 4 ha-m could only reduce flood volume by half, suggesting that the retention volume should be increased if land is available there. Overall, simulation results show that retention ponds are effective ecological engineering in mitigating flood volume and in increasing ecological services provided.

Storm water runoff draining into these retention ponds contain pollutants and nutrients that could lead to water quality problem as in the case of Tasik Harapan in USM campus. Hence, based on the insights derived from the in-campus study, mitigation measures that include pollution control and treatment systems installed on-site at source with periodic sediment dredging are required to maintain the ponds' hydrological and ecological functions.



No	Subcatchment/Region Name	Area (ha)
1	Sg. Pinang Catchment 1	289
2	Sg. Pinang Catchment 2	73
3	Sg. Jelutong Downstream Catchment	169
4	Sg. Air Terjun Catchment 1	114
5	Sg. Air Terjun Catchment 2	188
6	Sg. Air Terjun Catchment 3	774
7	Sg. Air Itam Catchment	1867
8	Sg. Dondang Catchment 1	116
9	Sg. Dondang Catchment 2	140
10	Sg. Dondang Catchment 3	262
11	Sg. Dondang Catchment 4	615

Fig. 5 **a** Sg Pinang catchment subdivision, **b** SWMM junctions and channels for Sg Pinang and **c** distribution of 13 retention ponds

4 Unifying STEM for Sustainable Management of Coastal Resources

The authors have been actively involved in national and global outreach initiatives to provide leadership in spearheading climate change adaptation (SDG 13) in preparing coastal communities to be climate resilient. The overarching objective of this initiative is to utilize the power of STEM in promoting a trans-disciplinary and sustainable approach for assessing and mitigating the adverse impact of climate change on coastal groundwater and vegetation. DESD and SDGs advocate integrating science and technology into other dimensions of SD to capitalize on synergy and inclusiveness. Mastery in Science, Technology, Engineering and Mathematics (STEM) will enhance achievements of SDGs. Further, STEM is crucial in preparing developing countries like Malaysia to adopt and excel in the Fourth Industrial Revolution. As science, technology and engineering are inherently very mathematical, it is self-evident that mathematical sciences are at the very core of STEM. A sustainable future for mathematical sciences involves connecting and integrating mathematics with science, technology, engineering and other disciplines. Unifying STEM to address pressing global issues of climate action (SDG 13) and other SDGs (14: Life below water and 15: Life on land) provide a convenient and convincing platform for universities to engage with each other and with local communities for better outcomes. Climate change (CC) spells a future characterized by unusual, extreme weather patterns and sea level rise (SLR), which are believed to be the reason why natural disasters such as floods, droughts, hurricanes and storm surges are occurring more frequently and more intensely than ever before. Global sea levels have been rising on average by 3 mm every year due to climate change. Malaysia is not spared from this global phenomenon as climate change is a global phenomenon. The mean sea level along the Malaysian coast is observed to rise at the rate of 2.7–7.0 mm/year. Many of Malaysian coastlines (e.g. in Penang, Kedah, Kelantan, Sabah, Sarawak) are affected by rising sea levels, with numerous parts of the country expected to be underwater by the end of the 21st century, affecting millions of Malaysians. Therefore, adapting to CC and employing disaster risk management are important to minimize this vulnerability. Seawater inundation and saltwater intrusion associated with CC impacts will cause a serious problem in the form of permanent salinization of fresh groundwater. Salinization of fresh groundwater has a negative impact on growth and productivity of plants. This threat to Malaysian coastal resources must be investigated scientifically and communicated effectively so that Malaysia can devise plan to cope with climate change impacts.

With STEM as a priority in Malaysia new education blueprint, this research will inspire a new generation of young people to take an interest and specialize in STEM subjects, encouraging them to integrate these otherwise seemingly disparate fields for solutions to real-world problems. This research project will serve to integrate Science (plant biology and hydrology), Technology (ICT and computer simulation), Engineering (coastal geo-physical data) and Mathematics (mathematical model and theoretical analysis) to address the challenges of climate change (CC). Achieving agricultural, food and water security is vital to adaption to CC. Declining water resources coupled with salinity intrusion into surface and subsurface water will pose threats to water security. Water scarcity, soil degradation and loss of cropland worldwide will have a profound influence on food security, leading to failure to achieve SDG 1 (no poverty), SDG 2 (no hunger). Worldwide, about 1.5–2 billion people rely on groundwater as a main drinking water source. Salt intrusion into aquatic ecosystems, wetlands, low-land agriculture (rice) and coastal plain groundwater systems pose a grave threat to freshwater resources, to whole ecosystems, to food production and to livelihoods. For example, more than 20,000 ha of rice paddy fields in three Tohoku region prefectures were flooded with saltwater from the infamous 11 March 2011 Tohoku tsunami (Roy et al. 2014). A year after the tsunami inundation, areas located within 3 km from the coast were found to be not suitable for rice pro-

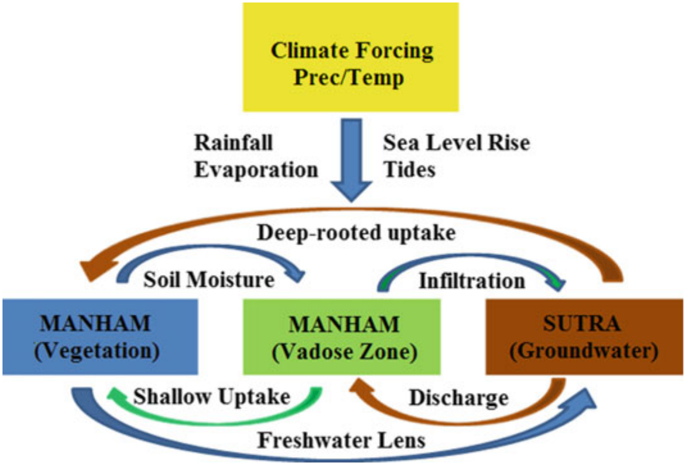


Fig. 6 A hydrology-salinity-vegetation model, forced by dynamically climate variables

duction. Rice production remained halted until 2013. Understanding the coupling of surface and subsurface water is crucial in achieving sustainable water resource utilization, particularly under the threat of CC. This project involves the development of a hydrology-salinity-vegetation model (Fig. 6) to predict the short- and long-term effects of: (a) water quality (i.e. salinity) on the soil and groundwater for areas exposed to salinity intrusion, and (b) the potential changes in vegetation in the affected areas (Fig. 7). Therefore, this research will offer a useful tool for sustainable management of coastal resources and provide useful insights on protection of coastal resources from threats and emerging threats from CC for adaptation to CC, fulfilling the SDG 13.

5 Discussion: Importance of Water Security in Achieving SDGs

In promoting SDG 6 and SDG 13 at the international level, SMS has focused on teaching and research programs that embrace global collaboration to achieve sustainable utilization and management of water resources in the face of CC adaptation. In this section, several case studies performed worldwide will be briefly reviewed to demonstrate the fragility and vulnerability of global water resources and to convey the important roles of SDGs in shaping a sustainable future planet. The availability of usable freshwater, both surface and sub-surface, is a foundation for human life, ecosystem health and civilizational prosperity. Predicted increase in surface water scarcity in local, regional and global scales coupled with accelerated fresh groundwater depletion is therefore a key challenge of the 21st century. Water scarcity is likely

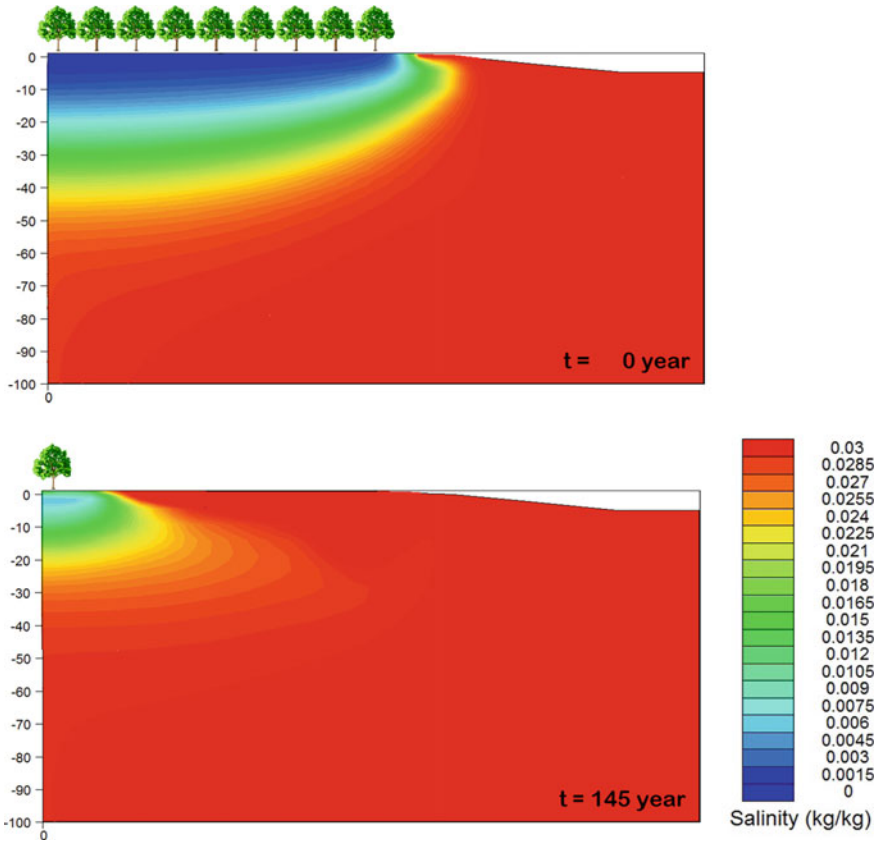


Fig. 7 Potential loss of fresh groundwater and vegetation due to climate change-induced sea level rise

to impose adverse impacts on agricultural outputs and on a variety of crucial economic activities, directly threatening food and social security (Cooley and Heberger 2013; Cooley and Ajami 2014; IPCC 2014). Climate change, population growth and increasing material affluent will compound this key challenge. Investment in human, social and institutional capitals, as well as in hard and soft environmental engineering, is essential in enhancing human adaptation to achieving water and food security and in meeting sustainable supply-demand balance in other natural resources.

Because of climate change, global sea level has been rising faster at an average rate of 3.1 mm per year since 1993 as compared to the average rate of 1.7 mm per year throughout most of the 20th century. Sea level could rise by another one meter this century. Most of this predicted sea level rise (SLR) is attributable to glacier melt and thermal expansion of oceans due to global warming. Based on Green House Gas (GHG) emission scenarios, the IPCC stipulates four representative concentration pathways (RCP2.6, RCP4.5, RCP6.0, and RCP8.5) to describe the 21st century pathways of GHG emissions and land use patterns (IPCC 2014). Predicted SLR induced by climate change will increase salt water intrusion in coastal aquifers. Against this background, Wassef and Schüttrumpf (2016) examine the impact of the expected changes in SLR in the Mediterranean Sea on groundwater salinity. Their simulations indicate that predicted SLR alone, without increase in groundwater extraction, could destroy parts of the protective offshore sand belt, which is already decimated by reduced sediment flows interrupted by the construction of dams in the Nile. Without this sand belt, recreational tourism and beach facilities will be inundated, and water quality in coastal fresh water lagoons will be adversely altered. This will vastly reduce the ecological services provided by the coastal seas and will have grave impacts on residents' livelihoods. Increase in groundwater extraction rates to accommodate population growth will further intensify salt intrusion. Where the groundwater extraction rates are low, SLR is the dominant factor driving groundwater salinization. On the other hand, where groundwater extraction rates are high, groundwater extractions become the dominant factor in driving groundwater salinization (Wassef and Schüttrumpf 2016). High groundwater extractions coupled with high SLR will spell disaster. Balancing groundwater extraction against predicted SLR is a daunting task requiring a coordination of a multitude of disciplines across different spatial and temporal scales. This is where STEM is critically useful.

In addition to salinity intrusion and depletion in groundwater due to accelerated extractions, a variety of pollution sources consisting of agricultural fertilizers, pesticides and industrial and domestic wastes, have imposed further constraints to the availability of fresh water for human life and ecosystem vitality. Understanding the extent of groundwater contamination and its causes are critical measures in managing groundwater availability and contamination. Towards achieving this goal, Narany et al. (2017) compiled a series of nitrate concentrations over a period of 25 year (from 1989 to 2014) to study the impact of land use changes including agriculture on the quality of groundwater in Northern Kelantan, Malaysia, where large scale deforestation in recent decades has occurred. The integration of time series analysis and geospatial modelling revealed that nitrate (NO_3–N) concentrations have significantly increased by 8.1 and 3.9% annually in agricultural and residential wells water respectively, over the 25 years. In 1989, wells with nitrate concentrations exceeding 10 mg/L covered only 1% of the total area studied. However, by 2014 that percentage has increased sharply to 48% of the total area, casting grave concern for the future of groundwater resources in Kelantan. This grave scenario is repeated elsewhere in many countries, including China and Europe.

Over in Europe, fifty years after its adoption, the European Common Agricultural Policy continues to support its primary goals of providing quality food at affordable prices (SDG 2: no hunger) and a decent standard of living for farmers (SDG 1: no poverty), while maintaining environmental health and ecosystem vitality (SDG 15: healthy life on land), simultaneously fulfilling many SDGs. Adapting to new challenges and articulating for sustainability in the era of SDGs, the policy empowers the preservation of the environment, nature and biodiversity in rural and agricultural areas. A study was conducted in Slovenia, a small EU country, to determine whether this policy has managed to maintain a balance between agriculture needs (SDG 1:

no poverty; SDG 2: no hunger) and groundwater quality (SDG 6: clean water). The study concludes that direct payments to farmers to support basic farmers income in the European Union, coupled with subsidies and investment grants has raised the level of pesticides in groundwater (Slabe-Erker et al. 2017). This finding implicates a problem of insufficient management of agriculture-environmental balance, requiring future refinement to achieve the EU goals on SDGs.

In Africa, despite the significance of the potential impact of climate change on water resources, a lack of adaptation measures to climate change, due to insufficient institutional capacity and sluggish economic development, is a daunting challenge to the attainment of SDG 13: climate action. Costly and unsustainable, surface water resources in Africa, consisting mainly of rivers and dams, are the only vital water resources. Looking to the future, groundwater resources remain the only reliable alternative yet to be available (DWA 2009, 2011). Groundwater is the only vital source of baseflow in most of South African perennial rivers, including the Olifants River (DWA 2013), providing for livelihoods in agriculture and domestic use for rural communities, especially in the Olifants River basin. However, climate change and groundwater contamination may pose threats, on which proactive research and adaptation remain elusive. Other water-related hazards of climate, such as droughts and floods, exert serious implications and complications for African countries' sustainable development (Nkhonjera and Dinka 2017). On this, Ziervogel et al. (2014) noted that research in climate change can be improved by addressing the following two issues: (a) the knowledge gaps related to inadequate impacts assessment and insufficient quantification of the socioeconomic costs of climate change and (b) the institutional challenges that make it difficult for organizations, in both the public and private sectors, to work and collaborate effectively to meet the country's adaptation needs to climate change. This observation is equally pertinent to many other river basins worldwide, including the Mekong River systems and several large river basins in northern China.

Worldwide conjunctive use of surface water and groundwater is a common practice in many irrigated agricultural regions, such as California, India, and Spain (Singh 2014; Scanlon et al. 2016). Groundwater plays two important roles in these systems. Firstly, groundwater increases total water supply for both agriculture and other sectors. Secondly, it enhances supply reliability by providing a stable buffer against uncertain surface water availability caused by climate variability and imperfect irrigation system management. Extensive research has been conducted over recent decades to quantify the buffer value of groundwater, including that in India (Palanisami et al. 2012). For California, Foster et al. (2017) quantified the impacts of low well-yields on the reliability of groundwater to buffer against variability in surface water supply. The economic value of groundwater in conjunctive use systems is evaluated through a case study of tomato production in California's Central Valley. The study concludes that groundwater should not be considered an unconstrained substitute for surface water as aquifer depletion has led to significant reductions in well-yields. Further, farmers with limited well-yields resources face increased production risk and higher profit volatility because available groundwater extraction rates are insufficient to satisfy crop water demands when surface water allocations are low during drought years. This uncertainty in water availability forces farmers to reduce irrigated area, forgo potential production, reduce profits and take on increased risks. Assessing the potential benefits of policy changes is essential in optimizing reductions in groundwater pumping rates and in minimizing imbalance in irrigated water supply and demand due to future fluctuations. Achieving the aspirations of SDG 6: clean water and sanitation cannot be taken for granted. This 4th World Symposium on Sustainable Development for Universities serves as a good platform to discuss, formulate and implement SDGs activities within campuses that could be scaled up to higher dimensions.

6 Conclusion

This paper serves as a demonstration of how modelling and simulation analysis can help address in-campus air and water environmental issues and how these STEM tools can be adapted to support implementation of SDGs within and beyond university. A potential air quality issue in USM was addressed via modelling analysis that had prevented the transfer of an air pollution problem to a water pollution and water consumption problem. A hydrological model was used to evaluate the effectiveness of the in-campus lake Tasik Harapan to serve as a flood retention pond. A hydraulic model was used to evaluate how flood retention ponds can reduce flooding in the Sg Pinang in Penang, subject to CC. These modelling tools provide invaluable insights and potential solutions to decision makers to sustainably conserve and manage the air and water environments within campus and beyond. Groundwater plays an important role in complementing the future sustainability of freshwater supply. But the availability of groundwater for agricultural, industrial and domestic purposes is threatened by the salinity intrusion induced by SLR. Therefore, the research initiatives in SMS involving surface waters have been expanded to sub-surface waters to address the consequences of global climate change on coastal water resources and vegetation. It is hoped that the research and outreach experiences presented in this paper can be adapted elsewhere as a model to be adopted to advocate and implement SDGs and sustainable development in teaching and research activities within universities and beyond.

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The Integration of Competencies for Sustainable Development: A Case of Study Programmes in a Non-elite University

Eglė Staniškienė and Živilė Stankevičiūtė

Abstract Recently, an increasing number of universities have embraced the sustainable development and convey their commitment by signing dozens of declarations and incorporating sustainability to a varying extent into their research, education, management, and administration. There is a general agreement that integration of competencies for sustainable development in study programmes can be treated as a relevant step towards sustainability. However, the distinction between the intentions and actual behaviour of leaders of study programmes as regards the competency integration is obvious in the number of universities. Moreover, the wording and meaning of the proposed competencies may not coincide. Considering the mentioned assumptions, there is a lack of evidence on the way the competencies for sustainable development are introduced in different study programmes, particularly in non-elite universities. The paper aims at closing the gap by revealing the extent to which the competencies are already integrated in study programmes in a non-elite university. Interviews were conducted with 15 heads of study programmes. Human resource management, Accounting, Economics and other study programmes were chosen. The results revealed that the relevance of competencies for sustainable development is still underestimated in the majority of study programmes. The analysis indicated that competencies for sustainable development related to critical thinking and collaboration are widely integrated, while competencies related to self-awareness or anticipatory and normative aspects are mostly absent. The paper calls for deeper and explicit integration of competencies for sustainable development in study programmes in non-elite universities.

Keywords Education for sustainable development · Competencies for sustainable development · Higher education · Non-elite university

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1 Introduction

Sustainable development (SD) is globally accepted as a concept to guide the decisions of various stakeholders coping with challenges such as lack of resources, climate change, loss of biodiversity, social inequity or poverty (Disterheft et al. 2013). SD calls for a paradigm change where education plays a key role (UNESCO 2009) and higher education institutions (HEIs) are supposed to take responsibility in promoting the SD principles (Lozano et al. 2015). HEIs can contribute meaningfully to the transition towards a sustainable society due to their dual role (Stough et al. 2018). Firstly, universities produce new knowledge, disseminate it and are expected to be thought leaders (De Lange 2013). Secondly, universities prepare students for their future role in daily life (Cortese 2003).

Universities can justify their role as the major agents of social change (Elton 2003; Cortese 2003) only if they respond to the SD imperatives in a systematic and serious manner. Therefore, in the last decade, a huge number of HEIs have been engaged in incorporating SD in all five elements of the university system: curricula, research, operations, outreach, and assessment and reporting (Lozano 2010). The level of SD integration in HEIs ranges from just "add-ons" to existing practices to fundamental transformations (Lozano et al. 2013a). However, in general universities have a very low-success rate in translating the SD promises into reality (Bekessy et al. 2007). The failure to achieve much progress also applies to the fields of learning and training of future professionals and integrating sustainability into the students' curricula.

Under the influence of social constructivism theory, HEIs adopted a competency-based approach (Van der Bergh et al. 2006; Stough et al. 2018)—a type of education that focuses on a clear definition of competencies, which are needed for future leaders. Within the context of higher education, different clusters of competencies for SD were defined (De Haan 2006; Roorda 2010; Sleurs 2008; Wiek et al. 2015; UNESCO 2017) offering a set of skills, knowledge, values and attitudes necessary to improve the sustainability literacy and deal with the economic, environmental, social and cultural issues (Lambrechts et al. 2010). The integration of these competencies in study programmes relies on the study programmes leaders. However, the difference between the intentions of these leaders and their actual behaviour concerning the inclusion of competencies for SD can be noticed. To explain this, the paper builds on the conceptual framework of Argyris (1999) introducing espoused theory versus theory-in-use. Espoused theory represents the way the people intend to act in a given situation and the rationale behind the intentions; theory-in-use reflects the way people actually behave. The next issue under consideration refers to the distinction between the wording and meaning of the same competency. It is important to establish the degree of coincidence between the competency wording from documents and the meaning of the same competency given by heads of study programmes.

Despite the numerous efforts to reveal how the sustainability is linked to the students' curricula, there is still little knowledge about the current stage of the integration of competencies for SD in different study programmes (Lozano 2010; Lambrechts et al. 2013). Moreover, current research provides the evidence from well-known universities (Leuven University College and Hogeschool-Universiteit Brussel (Lambrechts et al. 2013); KU Leuven (Stough et al. 2018), leaving non-elite universities offside. In the meantime, the issues of elite do not match the non-elite realities (Fornaciari and Arbaugh 2017).

The present research is aimed at answering the following research questions: (1) Does the wording of competencies fit the meaning of the same competencies provided by the heads of study programmes? (2) Which competencies for SD are treated by the heads of study programmes as most relevant in the context of study programme? (3) To what extent are the competencies for SD integrated in different study programmes? What are the intentions and actual behaviour of the heads of study programmes as regards the SD competencies? (4) What are the main barriers for the integration of SD competencies in study programmes? (5) What is the main value of integrating the SD competencies into the curricula?

To answer these questions, the paper presents the results from 15 interviews with heads of different study programmes in a non-elite-university. The research fits into Lambrechts et al. (2013) encouragement to reveal the current stage of integration of competencies in study programmes. The results give a review of the competencies a non-elite university wishes to cover in the curricula, however further research is needed looking at the students perceptions whether they have acquired these competencies.

The remaining parts of the paper are structured in the following way: firstly, a discussion on the linkage between sustainability and higher education underlying the competency-based approach and presenting the competencies for SD is provided; the next part describes the method used; then, the results and discussion are presented; and last section provides the conclusions.

2 The Linkage Between Sustainable Development and Higher Education

SD is treated as a contested concept (Disterheft et al. 2013; Stough et al. 2018), however there is a general agreement among scholars that the World Commission on Environment and Development (WCED) 1987 report "Our common future" has spread the currently best-known definition for sustainable development: "SD is the kind of development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (WCED 1987) Moving towards SD requires changing the mental models which influence our decisions and actions (UNESCO 2009). Education and learning are pointed out as core activities to facilitate the processes, which challenge the mindsets (Lambrechts et al. 2013) and develop new attitudes towards different cultures, nature and consumptions patterns (Adomßent et al. 2014). The institutionalisation of the concept of education for sustainable development (ESD) started in 1992 with the Agenda 21 (and specifically its chapter 36) at the UN Earth Summit in Rio de Janeiro (UNCED 1992).

Furthermore, the relevance of ESD has been recognised worldwide with the establishment of the United Nations Decade for Education for Sustainable Development (DESD) (2005–2014). UNESCO as the official leading international agency for the DESD defines ESD as "a process of learning how to make decisions that consider the long-term future of the economy, ecology and equity of all communities" (UNESCO 2005, p. 17).

In this context, HEIs have signed a lot of declarations demonstrating their commitment to embed the sustainability in their systems (Lozano et al. 2013b, 2015). The list of the success stories how the on-paper commitments were translated by universities into broad-scale, long-term mainstream changes is not impressive (Bekessy et al. 2007); however, some progress is apparent (Lambrechts et al. 2013). As the present paper focuses on curricula, the illustrations of the positive shift to sustainability encompass specialist courses in SD or interdisciplinary courses (Sleurs 2008), new pedagogical and methodological approaches (Ceulemans and De Prins 2010) or competencies for SD (Barth et al. 2007; De Haan 2006; Roorda 2010; Sleurs 2008).

Despite the mentioned achievements, HEIs are still seen as contributing to the sustainability crisis and "business managers are still being schooled into business assumptions that serve to exploit people and planet" (Tilbury 2011, p. 24). Disterheft et al. (2013) introduced several transfer problems that impede the paradigm shift towards the sustainability. Some of them will be shortly discussed as they are relevant within the context of this paper.

Firstly, universities remain traditional with strong disciplinary structures that hinder inter- and transdisciplinary approaches (Disterheft et al. 2013). As stated by Elton (2003), historically, universities have played a significant role in transforming societies while remaining remarkably traditional themselves. Meanwhile, SD challenges the predominant practices in higher education and requires from HEIs to follow the open-minded perspective. This is not straightforward as universities are considered as semi-open systems, where diverse resources enter the system, some of them remain in the system and some, after being evolved, exit from the universities (for example, students) (Lozano et al. 2013a).

Secondly, signing the declarations for higher education for SD does not ensure that HEIs implement SD in their systems. Lozano et al. (2015) highlight the "green wash" issue and Leal Filho (2012) warns that the majority of the declarations and action plans have never been fully implemented by HEIs. As stated by Bekessy et al. (2007), the process of change is complex and requires various strategies for success.

Continuing the debates on barriers for the SD implementation in learning and teaching, Lambrechts et al. (2013) underline that sustainability has been integrated into the curricula in piecemeal, rather than holistic approaches. According to Wals (2010), the rigid disciplinary structures of universities and content-based learning are the key barriers in integrating the sustainability in curriculum. Lambrechts et al. (2013) conclude that "until now, teaching and learning in HEIs has provided few opportunities for students to develop their own values, skills, and attitudes" (p. 67). Seeing that the attention given to competency-based education has recently grown, competencies can be the starting point for proper integration of SD in HEIs.

3 Competencies and Sustainable Development

The educational literature highlights the critical role of defining the key competencies in order to teach the academic programmes successfully (Baartman et al. 2007; Wiek et al. 2011). Competency-based approaches focus on the "output" of educational process and primarily ask what should be learnt instead of asking what should be taught (Hesselbarth and Schaltegger 2014; De Hann 2006).

The concept of competency is defined in many different ways; however, a common notion of most descriptions of competency is that it consists of knowledge, skills and attitudes (Baartman et al. 2007). Rieckmann (2012) emphasises that competencies may be characterised as individual dispositions to self-organisation, which include cognitive, affective, volitional (with deliberate intention) and motivational elements. In this paper, the definition of Rychen and Salganik (2003) is employed defining competencies as "the ability to successfully meet complex demands in a particular context through the mobilisation of psychological prerequisites (including both cognitive and non-cognitive aspects)" (p. 43). Moreover, in the literature, the differentiation between competencies and key competencies can be found (Lambrechts et al. 2010; Barth et al. 2007). Key competencies refer to those competencies useful and relevant for everybody and in different contexts (Lambrechts et al. 2013). They can be understood as transversal, multifunctional and context-independent (UNESCO 2017).

Introducing competencies for SD can be seen as a relevant step towards the SD integration in HEIs. Stough et al. (2018) see the value of competencies for SD in the fact that these competencies clarify "the broad and blurry" concept of ESD and enable the agents of HEIs to integrate ESD in different study programmes. However, to date there is no general agreement on a fixed and unified list of SD competencies (De Haan 2006; Roorda 2010; Sleurs 2008) and this could lead to the opinion that "literature is still dominated by the "laundry lists" of competencies rather than conceptually embedded sets of interlinked competencies" (Wiek et al. 2011, p. 204).

Table 1 gives a brief overview of the competencies for SD demonstrating some similarities and differences of various sets.

As can be seen from Table 1, De Haan (2006) introduces the set of "Gestaltungskompetenz" ("shaping competency") developed in Germany. The "shaping competency" encompasses a set of key competencies, which are expected to enable active, co-operative and reflective participation towards SD (Rieckmann 2012). As stated by De Haan (2006), "those who possess this competency can help, through their active participation in society, to modify and shape the future of society, and to guide its social, economic, technological and ecological changes along the lines of sustainable development" (p. 22). Roorda (2010) underlines that responsibility, emotional intelligence, system thinking, future orientation, personal involvement and action skills are the most important for education for SD. Wiek et al. (2015) defined competencies in sustainability "as complexes of knowledge, skills, and attitudes that enable successful task performance and problem solving with respect to real-world sustainability problems, challenges, and opportunities" (p. 242). Based

Table 1 Competencies for SD

Author (year)	Competencies for SD
De Haan (2006) "Gestaltungskompetenz", or "shaping competency"	Competency in foresighted thinking
	Competency in interdisciplinary work
	Competency in interdisciplinary learning
	Competency in cosmopolitan perception, transcultural understanding and cooperation
	Learning participatory skills
	Competency in planning and implementation skills
	The capacity for empathy, compassion and solidarity
	Competency in self-motivation and in motivating others
	Competency in distanced reflection on individual and cultural models
Roorda (2010)	Responsibility
	Emotional intelligence
	System orientation
	Future orientation
	Personal involvement
	Action skills
Wiek et al. (2015)	System thinking
	Future thinking
	Values thinking
	Strategic thinking
	Collaboration learning
	Integrated problem solving
UNESCO (2017)	Systems thinking competency
	Anticipatory competency
	Normative competency
	Strategic competency
	Collaboration competency
	Critical thinking competency
	Self-awareness competency
	Integrated problem-solving competency

on the provided definition, Wiek et al. (2011, 2015) introduced five competencies for SD and operationalised them as specific learning objectives for different educational levels. Recently, based on previous works, UNESCO (2017) introduced eight key competencies for sustainability arguing that these competencies represent the ones the sustainability-oriented citizens particularly need to deal with the today's complex challenges.

The actual presence of SD competencies in study programmes largely depends on the heads of study programmes. They are the key players in ensuring that HEIs are preparing students for dealing with complex and uncertain sustainability issues. However, the leaders of programmes focus on several challenges that are relevant for the scope of this paper. Firstly, the dilemma of wording and meaning (Del Sarto 2007) of competencies for SD. Wording refers to the description of a particular competency provided in documents, whereas the meaning refers to the understanding and perception of a separate competency provided by different actors. The heads of study programmes need to understand the wording of different SD documents universities have signed (declarations, strategy, plans) and to recognise and encode the true meaning of a particular competency. They are supposed to know precisely what the sustainability is and how it could be expressed in a university setting, including curricula. In the meantime, universities often just include the words "SD" or "competencies for SD" in the documents without expressly explaining what they actually imply. The distinction between the wording and meaning can cause difficulties in the SD competency integration process.

Secondly, there is a gap between the intentions of study programmes leaders and their actual behaviour as regards the implementation of competencies for SD in programmes. As stated by Bekessy et al. (2007), it is widely known that the adoption of SD declarations does not necessarily translate into the implementation of agreed commitments. Such gap could be explained using the framework of espoused theory and theory-in-use (Argyris 1999). Espoused theory represents the way the people intend to act in a given situation and the rationale behind the intentions; theory-in-use reflects the way people actually behave. The heads of study programmes can have intentions to translate the wording of SD competencies into study programmes, but certain barriers could prevent them from acting. Conservative culture, absence of leadership, lack of coordination, and financial constrains could serve as serious barriers in the described situation. The mismatch between the loudly announced on-paper commitments and explicit inclusion of competencies for SD in study programmes can be treated as an illustration of "green-washing" (Laufer 2003; Ramus and Montiel 2005; Bekessy et al. 2007). Actually, the form of SD competency implementation can vary significantly. Within the curricula, the so-called "built-on" (adding new courses and modules that contain elements of ESD) and "built-in" (integrating sustainability in the existing study programmes) approaches can be found (Watson et al. 2013; Wals 2014). The "built-on" approach could be called education about sustainability, whereas the "built-in" approach represents education for sustainability and aims at creating the connection between the subject in question and SD (Sammalisto and Lindhqvist 2008). Lambrechts et al. (2010, 2013) argue for horizontal (competencies are embedded into different courses), vertical (one specific course on SD) or combined integration and enumerate the strengths and weaknesses of each approach.

Based on the literature review, it could be stated that much work in the field of sustainability integration in education has been already done. However, little is known on the actual status of the integration of competencies for SD in existing study programmes in non-elite universities.

4 Methodology

The object of analysis was the integration of competencies for SD in a non-elite university. Generally, attribution of HEIs to elite or non-elite universities is based on the most well-known rankings of universities provided by numerous rating entities worldwide (Migliorini et al. 2010; Fornaciari and Arbaugh 2017). In the paper, the term "non-elite" is used to denote the university that is not a very highly ranked institution across all of its core missions (for instance, teaching, research) using The Academic Ranking of World Universities (ARWU), The Times Higher Education World University Ranking and QS World University Ranking.

ARWU is provided by Shanghai Ranking Consultancy and uses six indicators to rank the world universities, including the number of alumni and staff winning Nobel Prizes and Fields Medals, number of highly cited researchers selected by Thomson Reuters, number of articles published in journals of Nature and Science, number of articles indexed in Science Citation Index - Expanded and Social Sciences Citation Index, and the per capita performance of the university. According to ARWU data, the university where the research was carried out is not included in the list of the best 800 world universities (ARWU 2018).

The Times Higher Education World University Ranking uses 13 performance indicators to provide the most comprehensive and balanced comparisons, trusted by students, academics, university leaders, industry and governments. Based on this data, the university analysed in the present paper belongs to universities ranked in place 1000+ of the index (The *Times Higher Education* World University Rankings 2018).

QS World University Ranking uses six metrics: academic reputation, employer reputation, faculty/student ratio, citations per faculty, international faculty ratio, and international student ratio. Based on this data, the university analysed in the paper belongs to universities ranked in place 701–750 of the index (QS 2018).

To provide answers to research questions, a qualitative research strategy and a case study design (Eisenhardt and Graebner 2007) within the interview method were chosen. The research was carried out during October 2017—January 2018. Data were collected through in-depth, in-person interviews conducted at the non-elite university. The interview sample comprised 15 study programme heads, as it was supposed that they had the knowledge necessary to be able to answer the questions.

Each interview lasted 30 min on the average (ranging from 20 to 40 min) and all of them were recorded and transcribed. Qualitative data were analysed by coding and categorising the responses into the major conceptual areas.

During interviews, the questions about competencies for SD, were based on the set of competencies provided recently by UNESCO (2017) (Table 2).

Five main themes were covered during the interview: (1) Does the wording of competencies fit the meaning of the same competencies provided by the heads of study programmes? (2) Which competencies of SD are treated by the heads of study programmes as the most relevant in the context of each study programme? (3) To what extent are the competencies of SD integrated in the study programmes? What are the intentions and actual behaviour of the heads of study programmes as regards the SD competencies? (4) What are the main barriers for the integration of the SD competencies in study programmes? (5) What is the main value of integrating the SD competencies into the curricula?

5 Results and Discussion

The wording and the meaning of competencies for SD from the point of view of the heads of study programmes. At the beginning, it should be admitted that all interviewees indicated that they were highly aware of the SD principles. Sustainability-based commitments made by the university, and the university strategy which focuses on the transition towards sustainability were familiar to participants. However, knowing some information does not imply that the content and the meaning of this information is a part of daily life of the university and heads of study programmes.

As it was conceded, the majority of heads of study programmes treated the UNESCO's (2017) list of competencies for SD as a broad and extensive list. Some of the interviewees even raised the question that competencies for SD reflected the general key competencies, which were indeed relevant for the curricula. The majority of the heads of study programmes described precisely such competencies as system thinking, critical thinking, integrated problem-solving, strategic and collaboration. There were more difficulties with the anticipatory competency and only a few of participants were able to characterise clearly the content of normative and self-awareness competencies. The lack of knowledge about the normative competency or self-awareness competency revealed that it could be quite problematic to translate the wording of the mentioned competencies into the meaning. If people do not understand something, they are not able to implement the same in real life. Referring to study programmes, it could be problematic for some of the heads to integrate normative or self-awareness competencies in study programmes as they themselves do not realise the explicit meaning of the wording. Actually, the presented findings concerning the lack of knowledge in the field of SD are not surprising. For instance, Bekessy et al. (2007) found that leaders of Royal Melbourne Institute of Technology University felt the lack of knowledge what sustainability itself is due to its ambiguous definition.

Table 2 Competencies for SD provided by UNESCO (2017)

UNESCO (2017)	Systems thinking competency	The abilities to recognise and understand relationships; to analyse complex systems; to think of how systems are embedded within different domains and different scales; and to deal with uncertainty
	Anticipatory competency	The abilities to understand and evaluate multiple futures—possible, probable and desirable; to create one's own visions for the future; to apply the precautionary principle; to assess the consequences of actions; and to deal with risks and changes
	Normative competency	The abilities to understand and reflect on the norms and values that underlie one's actions; and to negotiate the sustainability values, principles, goals, and targets, in a context of conflicts of interests and trade-offs, uncertain knowledge and contradictions
	Strategic competency	The abilities to collectively develop and implement innovative actions that further sustainability on the local level and further afield
	Collaboration competency	The abilities to learn from others; to understand and respect the needs, perspectives and actions of others (empathy); to understand, relate to and be sensitive to others (empathic leadership); to deal with conflicts in a group; and to facilitate collaborative and participatory problem solving
	Critical thinking competency	The ability to question norms, practices and opinions; to reflect on own one's values, perceptions and actions; and to take a position in the sustainability discourse
	Self-awareness competency	The ability to reflect on one's own role in the local community and (global) society; to continually evaluate and further motivate one's actions; and to deal with one's feelings and desires
	Integrated problem-solving competency	The overarching ability to apply different problem-solving frameworks to complex sustainability problems and develop viable, inclusive and equitable solution options that promote sustainable development, integrating all of the mentioned competencies

The most relevant competencies of SD in the context of each study programme from the point of view of the heads of study programmes. All heads of study programmes underlined the importance of SD and the necessity to deal with competencies for SD in the framework of their study programmes. The findings differ only slightly comparing the undergraduate and graduate study programmes. The majority of the heads of study programmes emphasised that for undergraduate programmes, systems thinking, strategic competency and collaboration competency were of high relevance. Less important for the undergraduate programmes were integrated problem-solving competency and self-awareness competency. In case of graduate programmes, all competencies of SD suggested by UNESCO (2017) were treated by study programme heads as highly relevant. One of the interviewees commented: "I cannot imagine if and how our students could run business without having these competencies" (R4). Such attitude of heads matches the growing commitment of HEIs to SD expressed by integrating SD into different aspects of universities, also in curricula (Lambrechts et al. 2013).

The extent to which the competencies of SD are integrated in study programmes. What are the intentions and actual behaviour of the heads of study programmes as regards the SD competencies? The findings revealed that the integration of competencies of SD in study programmes at non-elite university is still underestimated. The heads of study programmes indicated that integration was deeper in graduate programmes; however, undergraduate programmes also strove to integrate competencies for SD. One of the heads shared his experience: "the integration of competencies of SD in a graduate programme requires less efforts as master students usually deal with real business issues which are mainly related with integration of 3 P—profit, planet and people" (R5). However, several respondents maintained an opposite position arguing that: "in our university, the duration of an undergraduate programme is 4 years and for the graduate programme we have only 2 years. This means that competencies in undergraduate programmes could be more clearly expressed" (R7).

It should be emphasised that study programmes differ by the pathways the competencies are integrated in study programmes. Several programmes have a compulsory SD course for bachelor and for master students. One undergraduate study programme has even two courses: a special SD course and also a Corporate social responsibility course. However, the majority of programmes employed a horizontal approach by embedding the competencies into different courses. Such findings are in line with Lambrechts et al. (2013) research, which revealed that competencies for SD are passed onto the students in an "unofficial" way, because they are not explicitly positioned within the context of SD. Moreover, it is highly complicated to determine which courses or programmes include sustainability aspects. As Stough et al. (2018) concluded, the approach used to assess the integration of sustainability in courses drastically influenced the results.

The findings of the current research disclosed that the systems thinking and collaboration are the most integrated competencies in undergraduate programmes. One head emphasised that: "our programme focuses much on relations between stakeholders, accordingly I am convinced that systems thinking competency is one of the highly integrated competencies" (R1). Less integrated was the anticipatory competency. As one head of a study programme claimed: "teaching how to deal with risk and changes in very complex world requires profound knowledge from staff and close collaboration with business. Evaluation of the future is a huge challenge" (R3). Normative, self-awareness and integrated problem-solving competencies were the least integrated in undergraduate programmes. This could be explained by the attitude of heads of study programmes as they, as it was told before, do not treat the mentioned competencies as relevant in the context of study programmes. Moreover, normative and self-awareness competencies were not accurately perceived by heads of study programmes and such mismatch between wording and meaning leads to poor integration.

The situation with the graduate programmes reflected essentially the situation with the undergraduate programmes. Systems thinking and strategic competencies were mostly referred to the group of competencies integrated in the study programmes. Self-awareness and normative competencies were lacking integration in the graduate programmes. According to one interviewee: "university cannot develop all competencies. We expect that students enter a university with some skills and attitudes. And this hope is related with such competencies as self-awareness or normative competencies" (R2). During the interviews, economic growth, environmentally friendly and socially responsible practices were mentioned as the main indicators showing that competencies for SD are part of programme: "our alumni are able to accept the decisions which are beneficial not only for stakeholders of the companies, but also for the society and environment" (R2).

The previous research mainly provided analysis using the key competencies for SD defined by Roorda (2010) or other authors, but not recently introduced by UNESCO (2017). That makes it quite difficult to compare the findings. Nonetheless, some insights could still be proposed. For instance, the findings concerning the integration of competencies are only partly in line with findings of Lambrechts et al. (2013) as the competency of system orientation is one of the most integrated competencies according to the recent research.

The study revealed a certain mismatch between the intentions and actual behaviour of the heads as regards the SD competencies. Heads of study programmes are part of university administration. It is widely known that leadership of administration is essential to achieve the SD goals (Bekessy et al. 2007). Although the heads acknowledged their responsibility for the implementation of SD competencies and emphasised the relevance of competencies, they did not behave proactively. The heads of study programmes relied heavily on teachers hoping that they would spontaneously integrate competencies of SD in their subject. Some of them said: "I think teachers include competencies for SD, I fully trust the teachers and, to be honest, it is impossible to document all the aspects; we believe that students acquire the competencies for SD" (R11).

The main barriers for the integration of the SD competencies in study programmes. Several barriers were mentioned for deeper integration of competencies in study programmes. One of the barriers was related with the duration of studies. Several interviewees stated that in graduate programmes it was quite difficult to devote much time for competencies for SD as the majority of students generally wished to acquire:

"deep professional skills about finance, marketing or human resource management" (R4).

Another barrier relates to the different structure of study programmes. As it was mentioned, some programmes have a special SD course and thus the students of these programmes are supposed to have deeper knowledge on SD. Almost all heads of study programmes mentioned that they would like to have a combined (vertical and horizontal) pathway for embedding competencies for SD in their programmes.

The third barrier quite frequently suggested was the insufficient maturity level of society: "people and young generation still are on the way to understanding that it is not too early to deal with all issues from the sustainable development perspective; we are significantly too late" (R7).

The main value of integrating the SD competencies. All heads of study programmes acknowledged the value of the SD competencies integration. The perception of value was based not only on ethical assumptions, but also on future leaders concept (Cortese 2003). A representative of one study programme underlined that: "competencies for SD enable the future business people to create the world we all would like to live in" (R2). The majority of heads ascribed the quality of bachelor or master theses to competencies of SD, as: "I believe that the integration of competencies for SD allows the students to demonstrate such skills and knowledge, which would be impossible without SD" (R3).

From the above analysis, it appears that there is no considerable distinction between different study programmes and different levels (undergraduate and graduate) as regards the implementation of SD competencies. Several reasons could explain these findings. Firstly, the University pursues a centralization policy and the main principles are applied to all programmes. Secondly, each head is responsible for both undergraduate and graduate programmes in the same field (for instance, finance, human resource management) and this could lead to programme assimilation in terms of competencies.

6 Conclusions

The study revealed that the heads of study programmes of a non-elite university prioritised the key sustainable development competencies such as systems thinking, strategic thinking and collaboration. Anticipatory, self-awareness and normative competencies appear at the end of priority list. Overall, the teachers' professionalism and expertise played the most important roles in the integration of SD competencies. The present study has shown that the role of teachers was overestimated. The heads of study programmes expected spontaneous integration of SD competencies into the curriculum, even it was not reported.

This study contributes to the literature on competencies for sustainable development in higher education, showing how the heads of study programmes of a non-elite university engaged in SD competencies' integration pathways. Empirical evidence shows the limitations of SD competencies integration processes in university curricula and the importance of multi-stakeholder involvement and understanding of the SD competencies integration process.

The study contributes to the perspective of the heads of study programmes to SD competencies integration. However, further research is needed to disclose the students' perspective: their perception of the SD competencies they attain can reveal the incongruity between the views of both stakeholders—students and heads of programmes. Studying the students' perceptions is critical for fostering the SD competencies and for reducing the gap between what is being done and what is perceived to be done (Watson et al. 2013). Finally, it would be helpful to see more studies, which seek to understand how the universities overcome the barriers for SD implementation in learning and teaching and integrate the sustainability into curriculum more holistically.

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Educating 'Future Professionals' for Sustainable Development: Piloting a Radical Nutshell Strategy for Organizational Change in Higher Education

Susanne Maria Weber

Abstract The article addresses the question, how sustainability education can be developed, explored and implemented by academic programs. A pilot program for transformational change is presented, which grounds Scharmers' (2018) claim for a 'vertical literacy' with transition theoretical, habitustheoretical, social innovation and future strategies oriented foundations. Social, cultural, ecological and economical sustainability are explored for institutionalizing sustainability into Higher Education. Against bureaucratization and individualized teaching, experimentation and exploration are to be implemented. The article suggests a radical 'nutshell strategy' of bottom up organizational change in Higher Education.

Keywords Students as resourceholders · Students as future professionals · SDGs, train the trainer program · Ecological university

1 Academia on Its Way to Sustainability…

The United Nations Sustainable Development Goals (UN SDGs) aim at ending poverty and hunger. They wish to contribute to health and wellbeing as well as to valuable education and equality of the sexes.

Within academic debates, there are a lot of suggestions and analysis, how to contribute to reach out for the SDG goals. Already in 2000, Scharmer and Käufer suggested to bring about a new nexus between research, teaching and practice.

Bastenhorst (2005) discusses the sustainable university from a resource perspective. He develops a multilevel sustainability perspective as goal of the sustainable university (2005, p. 84ff). While Schneidewind (2009) and as well Schneidewind

Youtube-Channel (with latest videos): http://www.youtube.com/channel/UCctbXCXpFUrWhjSeOkb71bA.

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and Singer-Brodowski (2013) ask for a transformation within the system of Higher Education and Academia, Peters et al. (2013) reflect on the different notions and qualities of the ‘creative university’. Tesar (2013) asks for ethics and subversion as alternative pathways in times of the neoliberal university and claims to maintain the university as a creative and ethical space. Swirski (2013) requests a third generation creativity, which unfolds a social-ecological worldview and imagination.

Also Barnett (2012, p. 441ff), in a philosophical perspective, addresses imagination as a core dimension for the transformation of our present university by differentiating four different basic patterns. As a possible alternative university for the future, he sees the rise of an ‘ecological university’, which takes the interconnectedness of the world serious and addresses the common knowledge creation between university and society. According to Barnett (2012, p. 451), a university like this becomes a ‘university-for-others’. In this sense, Scharmer (2018) argues, to focus on the level of emergence, of how we bring about the future, and at the level of awareness and consciousness. He suggests to make university a space of what he calls ‘vertical literacy’.

The following presentation of an academic pilot program for transformational change grounds Scharmers’ perspective with transition theoretical, habitustheoretical, social innovation and future strategies oriented perspectives. Within given administrative structures and financial situation, bureaucratization and accreditation, a radical ‘nutshell strategy’ of bottom up organizational change in Higher Education is suggested. First, the desiderata of a SDG fit Higher Education approach according to Otto Scharmer will be presented (2). After this, the program ‘Networkcoaching Future Designer’ will be briefly outlined (3) and the impact will be discussed based on the empirical results of a rolling program evaluation (4). Finally, possibilities for implementation and institutionalization of programs into regular modules of a BA Education will be suggested (5). The article ends suggesting the potential of educational ‘micro-innovations’ as a radical nutshell strategy for organizational change and Higher Education Learning (6).

2 From SDGs to Transforming the Space of Higher Education Learning

Students carry a huge potential in order to experiment with new formats for active, problem based, self-organized learning, which are seen as key to individual and collective education for sustainable development (Singer-Brodowski 2016; Bastenhorst 2005). University in this sense needs to open the space towards new platforms of learning, towards cross-sector-co-creation and the shift from ego-system to eco-system awareness. According to Scharmer, only deep systemic reflection of the arising future in an observing observer position, supports professionals and institutional reflexivity of operating ‘attentional orders’. Scharmer (2007) as well as Scharmer and Käufer (2013) see the shift needed from a habitual, ego-systemic, as well as an empathic towards an eco-systemic approach to the future.

According to Scharmers matrix of social evolution in attentional orders and communication patterns, the development of 'vertical literacy' is needed most in the educational sector and the volatile, uncertain, complex and ambigue realities (VUCA) we are facing today. Universities from this perspective are asked to become a learning environment, where learners learn to address their own way of listening and paying attention, their way to dialogue, to organize and coordinate, in order to develop a 'deep' mode of listening and dialogical qualities.

This alternative conceptualization and design of a 'university of the future' leads into curriculum innovation. So how can university intentionally be brought about as a different space and a learning space for a systemic 'ecosystem innovation'? The program 'NetworkCoaching FutureDesigner' realized at Philipps-University of Marburg, Germany wishes to support students in their biographical transition into university and right from the beginning addresses them as 'future professionals', as 'pioneers of change' for sustainable development. With the intention to transform university into an enabling context for sustainability education, the program carries transformative quality and contributes to a transformational education. It supports the transition towards another "great transformation" (WBGU 2011).

The approach of 'NetworkCoaching FutureDesigner' fosters early professionalization of students for change agents' abilities, as well as in strategy development for sustainable futures. The program is not only suitable for the humanities, social- and cultural studies or degree paths in economics—it can be beneficial in all academic fields. The approach developed and tested at the Department of Education Sciences (FB 21) at Philipps-University Marburg, Germany addresses topics which normally and so far are unlikely to be taken up in academia.

3 Addressing Students as 'Future Professionals': 'Networkcoaching FutureDesigners'

The program "NetworkCoaching FutureDesigne's" primarily addresses the SDG 4, SDG 5, SDG 10 and SDG 11. The program was funded and evaluated over a time period of five years by the national ministry of education and research (BMBF) within the national program 'quality pact of teaching' and now is being transferred into the regular curriculum.

The program goal of 'Networkcoaching Future-Designers' wishes to shape students' strategies for professionalization into sustainable futures right from the beginning and in a Train-the-Trainer approach. By addressing transitions, self-education, peer leadership training and social innovation development (Weber et al. 2018) as well as strategy development (Heidelmann et al. 2018), the program intends to support sustainability in Higher Education. In the following, the pilot phase design will be explained.

In the pilot phase, the Train-the-Trainer concept addressed the whole first semester cohort of students of roundabout 200 students starting a BA in Education. One third of this cohort either applied or was suggested by their peers for becoming trainers in sustainability education. They were trained in order to become trainers (called 'Coaches') for the two remaining third of the cohort of student newcomers (called 'Peers'). Within this "bottom-up approach" of self-organized small groups, these so-called multipliers showed and told others about the acquired methods of transitional support and design skills to their fellow students. With triadic coaching, students were enabled to master their institutional transition by entering Higher Education as "newcomer innovators" (Revsbaek 2015). The program had special awareness for students with a non-academic background (Lareau 2002) in order to support self-guidance towards a 'sense of possibility' instead of a 'sense of constraint'.

The program 'NetworkCoaching FutureDesigner' was designed as a two-hour weekly realized program. This format interconnected formal, nonformal and informal educational levels, insofar it systematically combined lecture, training and students' self organizing groups. Program content was linked to a lecture with the title "From institutionalized inequalities towards innovation potentials within the educational system".

Student 'trainers', funded by tutorial contracts, became active as MA/BA student tandems, each of them training groups 10–12 'Coaches'. 'Coaches' participated in weekly trainings and transmitted training contents of the weekly trainings to two or three of their 'peers'. Network 146 'Coaches' deliver the program content to two or three other 'peers' of their cohort 147 throughout the whole semester.

The program rationale was grounded in the approach of education for sustainable development (de Haan 2008), which defined the programs learning goals (Weber et al. 2018). The program connected transition theoretical, inequality perspectives with approaches to social innovation and future creation and like this integrated different theoretical frameworks like transitions, diversity orientation and social innovation. According to students' transition into university over the first semester, the program addressed four core-themes of Transition-Ability, Habitus-Reflexivity, Sense of Possibility and Design-Ability. Like this, the program wished to address and reflect symbolic and cultural orders as well as discoursive horizons into Higher Education.

3.1 Transition-Ability

In the first months of their studies, students' are in a transitional phase (Friedebertshäuser 1992). The program takes up and focuses on supporting transition-ability. Students are encouraged and trained for creative approaches to reflexivity and towards understanding their own biographical transitions within institutional settings. Transitions are theorized as collective transitions (Bourdieu and Passeron 1971) and biographical-institutional transitions are regarded as social 'trajectories', embedded in societal structures (Schwarz et al. 2015).

Connecting to de Haan's (2008) approach on education for sustainable development, the first three sessions in the starting phase of the program aims the goals (a) to motivate oneself to become active, (b) to motivate others, to become active, too and (c) to participate in decision making. The first three seminar sessions of the multiplicator-training address transitional experiences working with image based approaches, scenic plays and theatre approaches (Hentschel 2010). Using socio drama and theatre plays (Wildt et al. 2008), the program supports co-sensing.

3.2 Habitus-Reflexivity

Connecting to the inequality critical perspectives of Bourdieu (1987), in its second phase the program refers to reflexivity of students' habitual dispositions (Bourdieu and Wacquant 1996; Bourdieu 2004; Weber 2012; Elven and Weber 2012). The sequences' goals are to support students' reflexivity (Grundmann et al. 2006) within their specific societal backgrounds and developmental potentials and needs. Especially in the field of education, many 'first generation in Academia' students enter. By seeing different patterns of transitioning, students recognize the internalizing or externalizing beliefs of control, conceptualizations of self or others, which are hidden structuring patterns of success and developmental paths of practice, social relations and design (Grundmann et al. 2006, pp. 30–33).

Students' educational strategies (Lange-Vester and Teiwes-Kügler 2004) which differ according to social background, are explored (Bittlingmayer 2006, p. 54). Problems of match or (non-)fit between biographical dispositions and institutional requirements are faced here (Brake and Büchner 2012; El Mafalaani 2012; Elven et al. i.p.).

Learning goals of this section are (a) to be able to reflect ones' own 'leading and guiding images' ('Leitbild') and the guiding images of others, too. Secondly, (b) empathy and solidarity towards disadvantaged, poor, weak and oppressed become important learning goals. Students' learning for reflexivity bends the educational and pedagogical observation back onto the observing self, students learn methods to make them see themselves and the systemic and societal embeddings in which they are socialized into and constantly involved in.

3.3 Sense of Possibility

The third phase of the program addresses students as 'future professionals'. It invites them to develop their sense of possibility for creating and bringing about sustainable futures. Over the next three sessions, 'coaches' (multiplicators) support their 'peers' to design societal alternatives. Using methods like 'Appreciative Inquiry' (Cooperrider et al. 2003), 'Theory U' and the 'Presencing Approach' (Scharmer 2015a), 'Design Thinking' (Plattner et al. 2007; Weber 2014) support designing social innovations.

In self-organized groups, students develop and design alternatives to institutionalized inequalities. Learning goals of this section are, that students experiment in designing alternatives to established institutionalized inequalities.

They to (a) build knowledge by open mindedness and new perspective integration and (b) to gain wisdom by interdisciplinary reflection and to be able to act accordingly.

3.4 Design-Ability

In the last section, including three sessions, the program addresses design learning of one's own future strategies. Here, sustainability issues and problem solving for sustainable futures are core. Students as multiplicators are enabled, to (a) collectively plan and act together with others and (b) to plan and act foresightedly. The program connects to 'life work planning' methods (Bolles 1998) and works with a biographical and resource-based approach.

In total, in its' weekly turn, the program focuses four thematic fields over three sessions each, leads into understanding, analyzing, designing and creating the future. Systematic research, realized over five years shows the huge positive effects of this program. By training participatory and systemic methods, the program strengthens students' future designers' abilities. Students learn to train their peer students and contribute to transformative education (Kokemohr 2007). Education contributes to a change of self and world relations (Koller 2012). The program's value lies in the integration of novel concepts. It does only support mastering transitions, but also enables students to deal with heterogeneous groups of students and to foster social inclusion.

After having presented the program learning goals (3), empirical results of the program evaluation will be shown (4). As the program is interested in the effects and outcomes of evaluation, it uses learning goals primarily in order to transmit learning interests. Following an impact-oriented perspective, the program evaluation relates empirical and outcome oriented perspectives. In an inductive qualitative analysis of 14 group discussion (which is the total of 72 involved 'coaches' being trained in the program), program impact will be discussed. We will see, that the program is perceived as an 'alternative space' of the university.

4 Researching and Analyzing Impact

The analysis and empirical results of the mixed method program analysis shows, that approximately 180 "newcomer innovators" have been trained as 'Coaches' and roundabout 600 have been participating as 'Peers' in self organized students' first semester groups.

The program was consistently evaluated in a multimethod and mixed method research design (Brake 2015). At the beginning of the program in 2012 and 2013, guideline and image based interviews (Weber 2012) had been combined with a quantitative study following the Survey Feedback approach (Weber and Wieners 2018). Over the following years, qualitative and image based group discussions and group workshops were combined with quantitative formative and final evaluations. In general, program outcome was analyzed from students' perspective via annual surveys and data gatherings. For data analysis, a reconstructive approach based on the documentary method was applied (Bohnsack et al. 2013).

The program wave 2016/2017 involved 12 trainers, 60 Coaches and 120 Peers. The mixed methods approach combined quantitative and qualitative evaluation in a midterm and final evaluation approach. As the results of the quantitative evaluation were very good in general, we will focus here on the qualitative final evaluation results based on 14 image based group discussions. Data Analysis was done in a research team working with 'Documentary Method' (Bohnsack 2014), analyzing program outcomes in students' perspectives. Like the complex analysis of qualitative data shows, students perceive the program as a completely different educational experience. As we will see in the following, the program is regarded as 'Different Space' (Foucault 2005).

In 2017, six trainings were realized in parallel trainings of 10–12 participants each, who were trained by a tandem of student trainers. 60 student multiplicators ('coaches') were trained, who each supported two or three peers in their weekly peer-group trainings.

5 The Program as Different Space

This different and alternative space can be analyzed regarding the dimensions of being a space for entry, transition and orientation. Secondly, it is a social space of friendships and relations, thirdly a space of explorations and experiences, and in total an atmospheric space. It can be discussed as a heterotopic space according to Foucaults' perspectives on alternative spaces (Weber et al. 2018).

A biographical space of passage, transition, entry and orientation

For many of the participants, the program becomes a relevant biographical space of entry and orientation. Entry is being described as well as entry in studies and entry into a space of recognition.

(…) I believe, that Networkcoaching helped me to orient myself better – especially in the beginning (Lina-Thau[1] Group 7 p. 3 l. 81–82).

The program in total manages to make students become active for themselves and as well enables them to activate others. In this sense, the program contributes to SDG 10 and SDG 4.

A space of friendship and relations

A second dimension of the alternative space brought about is to be found, when looking at the program as a space of social relations, of friendships and personal bonds.

it wasn't – we just meet in order to do Networkcoaching, but it was even related to partly a friendship level, too, I would say //mhm//it was simply – well - contacts like this you won't lose easily and this is - for a student life it is an enrichment (Lu Group 10 p. 25, l.1210).

In the facet of support, exchange is related to mutual help. In contrast to a distance, perceived as normality in university's social relations, proximity, closeness and friendship relations are mentioned here:

So you know and often have a very personal relationship to the participants of the program, what I – like this - not have perceived so far at university, normal tutorials were much more 'distanced' than Networkcoaching. It brings about a very special experience, as you are in so close contact to other students (Kä Group 2 p. 2 l. 85–90)

As we can see, the second program meta-goal of 'habitusreflexivity', of empathy and solidarity as well as reflexivity are addressed by students.

The 'different space' as space of exploration and experience

Students clearly perceive differences to other tutorial programs, which are oriented towards knowledge transmission. Students address a different social space emerging in the program.

One felt at ease, one learnt practical things. I really liked that, I mean, study programs normally are very theoretical and – one somehow really felt that in the program you are really learning something. (Lea Group 7 p-8 ff. l.70–77).

Students becoming active members of a learning community and taking responsibility for the professionalization of their peers to them is meaningful practice learning.

According to the perception of students, it supports bringing about self assureness. It contributes to involving everybody and to support professionalization:

(…) I felt that by networkcoaching I gained security and I gained security regarding my own abilities (H. Group 9 p. 9 l. 386–389).

Learning about their own abilities and clarifying their interests, goals and reflexivity is mentioned as well as the dialogue within the peer group. Students create a space of co-creation and of co-learning.

[1] All here and in the following mentioned names were anonymized.

The 'atmospheric space' as space of speakabilities and sayabilities

All these different facets unify in a collective narration of difference and a different space. In this narrations, we can see a different quality of university emerging. It refers to a created, socially designed and pedagogical space.

Trainers perceive this as an atmospheric arrangement. As a pedagogical project it allows 'low-threshold articulation' and speakability of concerns and critique:

> (.) I definitely had the impression, that it depends a lot on us trainers, to which extent they really speak out, to criticize things and to address negative things especially in the first semester – I didn't dare to do so and well I was a much more shy student in the beginning. It really made me happy to be able to create an atmosphere, where everybody felt at ease and people said what they thought (Kä Group 2 p. 16 l. 765–774).

Transitioning into university students perceive the program as an unfolding biographical space of entry and orientation. Secondly, it unfolds as space of 'friendship and relations'. Thirdly, we can see an explorational space and space of experience. Fourthly and in a comprehensive perspective, the program unfolds as 'atmospheric space'.

The program especially supports articulation and voicing of those students, who normally would not dare to speak. In this sense the program supports democratizing university as an organization. As students take responsibility for themselves and for others, they enter into the students' union and membership rates of the students organizing themselves rise enormously. Students discover university as a space of co-design and co-creation. Students' engagement changes the organizational context, too. They start to speak out and challenge the system. The program in this sense brings about a difference. It shows a 'Heterotopia' in the Foucauldian sense (2005, 2015). This specific quality not only is to be found in the atmospheric differences. It especially unfolds by students speaking out and articulate whatever is crucial and critical.

The 'atmospheric space' as space of 'vertical literacy' and co-creation of future

After reflecting on their habitual positionings, the program asked students to design societal alternatives. By using collective approaches of system sculpting, students created prototypes for institutional change and sustainable societal solutions. With the topic of habitusreflexivity, students were able to professionalize self observation. The program topics 'systems thinking' and social innovation supported participatory innovation learning. Students unlocked their creativity and became literate in "aesthetics" and the cultivation of the senses. Within the program, the social field of a committed training group was created. It showed to be a strong gateway for student learning (Scharmer 2015b). By working with 'journaling' methods, the deeper sources of knowing were addressed. In this sense, the program supports 'vertical literacy' (Scharmer 2018) and collective co-creation of our common future.

Following the Foucauldian question "Who speaks?" (Foucault 2005), we could see students' democratization. The empirical analysis of the program shows, that it is indeed an institutional enabling space within the university. It emerges as a counter space, a counter placement and a counter bearing (Foucault 1992, p. 39).

It brings about students' speaking and different self-concepts to the given. Working on crisis like transitions, it creates different social relations, creativity, design and facilitation.It supports articulation of former non-speakabilities.

The program 'Networkcoaching FutureDesigner' offers new methodological approaches. By this it enables students to successfully create their paths into sustainability professionalization and sustainability innovation. Based on de Haan's (2008) education for sustainable development, the program connects to the 2030 goals of sustainable development in Higher Education. It offers a nucleus of the sustainable university.

6 Micro-institutionalization: Nutshelling a Nucleus of the 'University for Others'

As Schneidewind (2009) as well as Leal Filho et al. (2018) show, research curriculum development and campus management provide institutional barriers as well as critical success factors for the integration of sustainability approaches into Higher Education.

The funding of the program 'NetworkCoaching Future Designer' showed to be critical for institutionalization. Barriers referred to institutional integration, networked styles of curriculum development, an integral approach on sustainability issues etc. Even without funding and support, still it is possible, to establish and institutionalize a sustainability nucleus in educational programs and like this to raise conscience and concern (Leal Filho 2017, p. 102). SD policies and programs then enter like a nutshell strategy. Without specific personnel and funded on an ad hoc basis, without an institutional sustainability policy or overarching sustainability programs it still will be possible to shape students' education towards sustainability (Leal Filho 2017, p. 204).

Imaginative Subversion

A dystopic imagination would question, that there are realistic alternatives to the present. Barnett (2012) sees the need to change the neoliberal university. This impoverished, narrow and dominant concept lacks considerations of global and personal wellbeing. It lacks 'hope' and visions of the future. Against this dystopic perspective, the program's institutionalization locally supports a 'feasible utopia'. Here, possibilities are identified, values and embryonic practices are established and verified. Institutionalizing the program will be an 'imaginative subversion' and a pedagogical micro-innovation.

From 'Backpacker Strategy' to Micro-Innovation: Using given spaces of autonomy

The pilot project had been kind of a subversive "backpacker" strategy right from the beginning. The ministry wished to address the challenges of the mass university, the access into Higher Education, the challenges of rising heterogeneity and student's drop out. As we could see, reforms of the study entry phase offer potential not only for student dropout prevention. It allows to integrate social and ecological dimensions of sustainability. As the program gained acceptance with students and faculty, reaccreditation will establish the program as lecture interlinked course. Situated in one of the modules of the BA in education at Philipps-University of Marburg, Germany, in its' institutionalized future, the program can become a micro-innovation for sustainable development.

Students as Resourceholders and Newcomer Innovators

Especially students can be important partners for institutionalizing sustainability programs. All over the five years, the program was rated excellent by students. Bastenhorst (2005) suggests, to regard students not as stakeholders, but as resource holders. In this sense, students will be trained to organize self-organization, to take leadership and responsibility for others, to develop visions, to create feasible alternatives and to professionalize in a complex set of relationships. It shows, that Higher Education can change (Singer-Brodowski 2016, p. 33) and didactically support innovation.

Multiplying Forces by Train the Trainer Strategies

The train the trainers 'Coaches' relate to their Co-Coaches and create a common source of collective learning (Singer-Brodowski 2016, p. 198). They learn reflexivity, democratic engagement and bargaining. They train to find solutions and to deal with dilemmas. Especially self-organization supports transformational and transformative experiences. The students' self-education approach multiplies effects.

Following Barnett (2012), imagination should flow unconstrainedly, envision new possibilities and find new languages, new 'conceptual grammars'. Program implementation of and within Barnetts' (2012) 'ecological university', establishes the criteria of range, depth, feasibility, ethics, possibilities and emergent properties.

Moreover, the dimension of multiplication needs to be added to this. A one third training strategy supports the reaching out to the whole cohort of another two third. Like this, scalability can be strengthened as a design principle for sustainability. Multiplying forces creates solidarity and engagement, too. Institutionalization of the train-the-trainer approach leads into an "intentional reconfiguration of social practices" (Schwarz et al. 2010, p. 167), possibly remaining stable over time.

Implementing Education for Sustainability: A 'nutshell' strategy

Bottom up 'nutshell' strategies can emergently support the "creeping in" of change into institutional strategies. 'Heterotopic' institutionalizing activities can happen in small, autonomous 'cells' or nutshells, which can't be easy controlled by the institutions. Nutshell innovations slip through the system. They simply stay in the individual range of decision and autonomy of professorships and academic workgroups. Like this, they may be still highly effective regarding their educational and institutional effects: They introduce the sense of an "embryonic society" (Dewey 1899) and sustainable citizenship education into Academia and Higher Education. For Barnett (2012) this project is related to sustainability, to ecology and to wellbeing. In the mode of a multilayer-social movement organization, it develops the nucleus and nutshell strategy of the ecological "university for others".

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Part III
Sustainability Processes and Practices

Building Collaborative Partnerships: An Example of a 3rd Mission Activity in the Field of Local Climate Change Adaptation

Hardy Pundt and Andrea Heilmann

Abstract Reacting to climate change on the regional level requires strategies that take into account various actors. Administrations as driving forces, but also NGOs, enterprises, and citizens should collaborate to achieve sustainable decisions. Universities can moderate between the different actors due to their independent and science-driven perspective. In such a way, building collaborative communities is an indispensable requirement for achieving consensus between different interests, goals, and approaches. The project "BebeR", presented in this chapter, follows such an approach. As an additional element, citizen science, an opportunity to consider the participation of people who are not tied to scientific work in the development of climate change adaptation measures, can contribute to the enhancement of the acceptance of decisions and became part of the project. The collaborative approach as it is applied in the project "BebeR", in which a university is not only the coordinator, but in particular the moderator, indicates clearly a 3rd mission activity whereby the university outreaches to local communities, organisations, enterprises, and the public. This requires adequate communication structures, as well as transparent IT-support. All components and the diverse participants form a living laboratory. The chapter presents the overall approach, and the process of building the collaborative partnerships. Some insights into the methods and IT services that proofed to be effective supporting tools will be given. Restrictions, limiting factors and barriers are discussed and conclusions are presented as well as recommendations for future work.

Keywords Climate change adaptation · Collaborative project · Participation · Citizen science

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1 Introduction

Climate change occurs since planet earth exists. However, due to scientific measurements during the foregoing decades it is very likely, if not sure, that current climate change is at least accelerated by human activity, foremost the emission of gases that increase the warming up of the lower layers of the atmosphere, such as CO_2, but also N_2O, CH_4 or gaseous H_2O. The achievement of a low carbon, resilient and sustainable future as a reaction to climate change, is increasingly recognized by most nations. The Sustainable Development Goal 13—Climate Action addresses mitigation and adaptation activities (United Nations 2018).

The adaptation to climate change is one of the crucial areas which have been and are addressed. The UNFCCC stated that "Adaptation, in the simplest terms, refers to the actions that countries will need to take to respond to the impacts of climate change that are already happening, while at the same time preparing for future impacts. Successful adaptation activities also call for the effective engagement of stakeholders—including national, regional, multilateral and international organizations, the public and private sectors, and civil society and the management of knowledge for adaptation at each step" (UNFCCC 2017).

The citation addresses clearly the need for globally harmonized actions. Apart from global agreement, the concrete consequences of climate change take place on a regional, or local level. Flooding, heat waves, erosion or other events affect specific regions, or local places (UKCAS 2018; Brebbia 2017; van Oosterom et al. 2005). The measures to mitigate negative implications require communication between different actors in particular. Acting collectively to achieve sound solutions concerning climate change adaptation is strongly dependent on an effective dialogue among academics and practitioners, aiming at dealing with the issues, matters and problems in a coordinated way. The actors that have to be included vary and increasingly it is observed that only a commonly coordinated course of action on the local scale helps to accomplish sustainable results. Such actors can be responsible persons from local administrations, NGOs, other organizations, enterprises, research institutes and the public. The people to be involved can have very different tasks, perspectives, and their contexts can be diverse. Rainfall, for instance, can have impacts that "(…) are not only related to precipitation itself, but also the socioeconomic aspects of the population involved" (de Araujo Moreira et al. 2017, p. 169). To coordinate diverse actors in a common network that is aimed at reducing harmful implications of climate change, universities can play a crucial role.

On a local level, tangible measures can be developed and implemented to achieve mitigation. Administrations, as well as organisations and companies on the local level, are faced with a bulk of new challenges in view of climate change. Additionally, the inclusion of citizens into decision making procedures has been identified as being important when dealing with problems that possibly could be solved more sustainably if knowledge of local people can be included. In such a sense, climate change adaptation becomes a field of very different, complex problems and issues that can only be solved if all concerned actors are included in an intertwined decision making process. This requires collaboration between administrational units, as well as between administration, the private sector, and citizens. To make collaboration effective, a suitable management strategy is required that includes the function of a coordinating and moderating instance. This can be executed by an independent organisation that has both, knowledge in the field of climate change adaptation, and project management capabilities. Research centres or universities are examples of such instances. They are capable to collect, analyse and evaluate the data and results of actors, and weight and interpret them independently and free of economic or any other interests. They do this in close cooperation with all partners aiming at finding the most suitable consensus.

Within the framework of a pilot project, carried out in the administrative district of Mansfeld-Südharz, Germany, a local climate change adaptation strategy has been developed and finalized in previous years. The cooperation of diverse actors from practice, working in public and private organizations, as well as researchers, was one of the main reasons that practically useful results were achieved during this project. An optimization, and possibly a better acknowledgement of measures within local communities, is an aspect to include citizen science approaches as an additional source of expertise. However, whereas public participation normally leads to specific measures, citizen science is an open and unbiased process.

In a follow-up project, called “BebeR”, aimed at reducing erosion in small river catchments induced by heavy rainfalls, as they are presumed to increase due to climate change, this kind of collaboration between different actors is envisaged to solve spatial and climate related problems in a multi-dimensional way. Multi-dimensional way means that the different perspectives concerning an environmental problem are considered adequately and balanced. Such different perspectives occur due to the varying interests and tasks that the relevant actors have. Therefore, the moderating instance, a universities working group with long term project management experiences, explicitly takes into account these experiences as well as expectations and requirements of the actors. In such a way, the “BebeR”-project has significant characteristics of a living laboratory, “a kind of giant sandbox in which there is the freedom to explore—creatively and collaboratively—the technological, environmental, economic and societal aspects of sustainability” (UBC 2018), thus focusing on problems of climate change. However, due to the different sectors and perspectives that occur in such a project, limiting factors and barriers were experienced as well. Such restrictions must be dealt with in an adequate manner. Some aspects related to those limitations are discussed later on as well.

2 Building a Network of Relevant Actors

The following sections refer to different aspects of collaborative work that apply to the project “BebeR”, which is described in more detail in Sect. 2.2.

Fig. 1 A hierarchy of different types of "working together" (*Source* CB 2018)

2.1 Requirements for Effective Collaboration

Networking is based on collaboration between different actors. Collaboration, however, "is a working practice whereby individuals work together to a common purpose to achieve business benefit" (AIIM 2018). Collaboration is sometimes seen as the highest level of "working together" or "teamwork", as Fig. 1 suggests.

The definition is widened by describing in more detail two types of collaboration that both have significance for the project described here. In such a sense, collaboration enables individuals to work together aiming at achieving a defined and common "business" purpose. The two types of collaboration are (AIIM 2018):

- Synchronous, where everyone interacts in real time, as in online meetings, through instant messaging, or via Skype, and
- Asynchronous, where the interaction can be time-shifted, as when uploading documents or annotations to shared workspaces, or making contributions to a wiki or an online forum, or blog.

Both types, synchronous and asynchronous, have significance for most projects that aim at bringing together various people from different interest groups, or sectors. Within the framework of the project "BebeR", they do not exclude each other, but complete the set of tools, analogue and digital, to achieve effective communication structures and therefore a high amount of consensus between actors. In addition to Fig. 1 there are also different levels of co-operation in the field of citizen science like passive observation, active participation, co-production and co-design which can play a role (Bonn et al. 2016, p. 17).

After a brief description of the project "BebeR", the main tools and measures will be elucidated to enlighten their benefits.

2.2 Tools and Measures to Implement a Dialogue Between Academics, Practitioners, and Citizens

2.2.1 Project Framework

The "BebeR"-project fits into several national activities that are aimed at mitigating the consequences of climate change on a regional and local level. The focus is on soil erosion, which is an important part of the strategy: "In connection with the German Strategy for Adaptation to Climate Change (DAS), regional statements on the vulnerability of soil to climate changes are required to develop a perspective on long-term adaptation strategies" (UBA 2016).

The pilot region for project "BebeR" is the administrative district of Mansfeld-Südharz. This district is situated in the south of the German federal state of Saxony-Anhalt and covers an area of nearly 1450 km^2. Land use in the rural areas is dominated by agriculture and forestry.

The administrational authorities of Mansfeld-Südharz have been working on local climate change adaptation measures since 2011. The work has been carried out during two phases. The goal of the first phase (project "Klimpass", 2011–2012) included the compilation of a local adaptation strategy. Within the second phase (project "Klimpass-Aktiv", 2013–2016), the advancement, implementation, and evaluation of specific adaptation measures were envisaged. The development of interactive vulnerability maps and the improvement of networking of relevant actors using internet technologies and Web-GIS (-geographical information systems), were key elements (Pundt et al. 2017).

The project "BebeR", running from 2017 to 2019, is looking especially at the improvement of the existing methodologies for soil erosion vulnerability assessment on a local scale. Furthermore, measures to mitigate erosion are envisaged. Soil erosion has been identified as a seriously pressing problem within the region. Two river catchments were selected for closer observation. For these catchments, all relevant actors dealing with water management and soil protection issues, were identified. Datasets from different providers were collected aiming at describing the catchments and the flow processes with the help of suitable computer tools, e.g. simulation models. The basic data and the results of analyses are presented to all interested parties. This is done mainly through maps, which requires easy-to-use Web-GIS-tools, accessible for all partners. Communication structures were established thus containing traditional forms, such as workshops and meetings, and internet-based forms, such as a digital forum. Both enable project partners to participate interactively in the development and critical discussion about climate change adaptation measures.

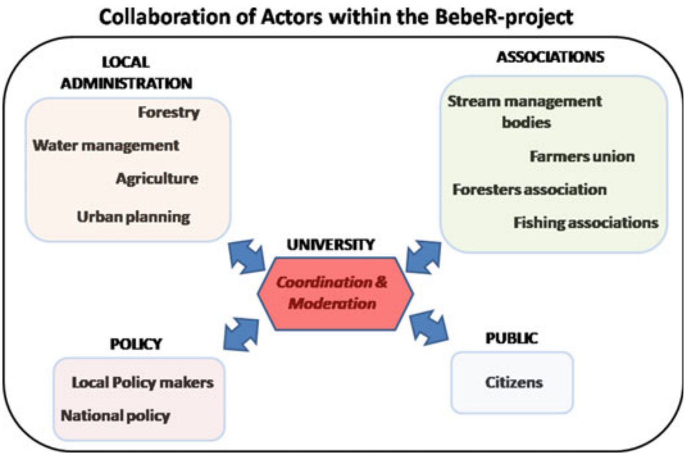

Fig. 2 Actors within the "BebeR"-project: collaboration in a living laboratory aiming at finding consensus concerning sustainable climate change adaptation measures

2.2.2 Actors in "BebeR"—A Rational Appeal to Collaborate Under Moderation of a University

As mentioned before, it is crucial that climate adaptation measures are handled using a comprehensive, commonly appreciated approach concerning which different perspectives and contexts are considered appropriately. This means that at least all relevant actors have to collaborate to achieve sustainable goals. The collaboration, however, is often hardly achievable due to several restrictions, limiting factors and barriers between administrational units, as well as other organizations. Furthermore, large amounts of data that must be used within the framework of the development of climate change adaptation measures require proper collaboration of data providers, and users. Possibly, data coming from citizens can complete the datasets and thus contribute to qualitatively better results. In such a way, the actors can be distinguished into stakeholders (like representatives from administrative authorities, forestry or agriculture) and the public (e.g. citizens, members of NGOs). An additional actor is the university that initiated the project. Figure 2 shows the overall collaboration structure within "BebeR", where the universities role is indicated as one of a coordinating and moderating interface between all relevant partners.

2.2.3 Processes to Support the Development of Climate Change Adaptation Measures

"BebeR" is requiring a sufficient basis of supporting computer and web-tools, or "electronic workspace", for networking across governmental and non-governmental bodies, and the public (Pundt et al. 2017; Brennan et al. 2012). These tools help to

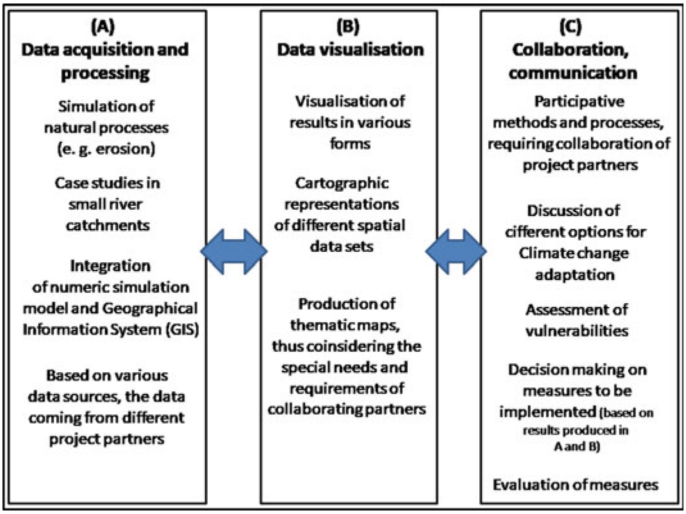

Fig. 3 Simulation, visualization and participation are important pillars within "BebeR", thus requiring collaboration between project stakeholders

overcome geographical barriers as well as time constraints by allowing all stakeholders to:

- access the information necessary (passive involvement)
- provide their own input and (active participation)
- engage in a constructive discourse with other stakeholders (active participation)
- participate in the research (co-production).

Figure 3 illustrates the structure of the computer tools used within "BebeR". It involves three main elements: (a) simulation, (b) visualization, and (c) participation.

(a) *Data acquisition and processing:* Data, foremost spatial information, is provided by various actors, including citizens. The data is coordinated by the university that integrates the different datasets as part of an online mapping system. The simulation tools will be developed by experienced scientists from a partner university that have a special focus on river catchment management. The goal is to simulate the erosion behavior of the past and calibrate the models based on historical events (the data can be delivered by actors via the website). Based on this, scenarios will be developed which should help to get insight into potential changes concerning the future erosion behavior, thus considering future climate change induced weather events. Scenarios are based on different climate projections whereas the simulation of case studies also takes into account possible adaptation measures. They have to be discussed with the stakeholders and concerned people, e.g. local inhabitants, during the project. Simulation utilizes data, which are gathered either from official sources or from stakeholders involved.

Citizens can play an important role, e.g. if they have experiences about facts and processes that can contribute to assess critically alternative adaptation measures.

(b) *Data Visualization* (including the verification of external, not official data, e.g. data collected by citizens) is carried out by the universities' scientists. The vulnerability maps encompass spatial data and scenarios [see (a)] in a transparent manner and are suitable instruments for planning and communication purposes. The latter is also an important issue to increase the willingness of inhabitants to implement measures for self-protection (e.g. defense of threats to their estates regarding mud flows from near slopes, or flooding from close rivers).

(c) *Collaboration and communication* are central characteristics of the "BebeR"-project. This concerns data provision and—processing, the cartographic visualization of results in 2D and 3D, and the development and evaluation of climate change adaptation measures. In all areas (a–c) the intensive and critical discussion among the project partners is indispensible. Again, it is easily visible that the building of a collaborative network, representing all relevant actors, becomes a central factor for the successful processing of the project from start to end.

2.2.4 Inclusion of Citizens

Citizens are increasingly observed as important data and knowledge deliverers. The goal is to build partnerships "between volunteers and scientists to answer real world questions" (Cohn 2008). The EU published a green paper in 2013 and, as a result of an intensive discussion process, the white paper on Citizen Science was published in September 2014 (Socientize Consortium 2014). According to the green paper "Citizen Science has been used to define a series of activities that link the general public with scientific research. Volunteers and non-professionals contribute collectively in a diverse range of scientific projects to answer real-world questions. Both citizens' contributions and researchers' attitudes encompass a wide set of activities at multiple scales." (Socientize Consortium 2013).

This citation goes along with what is supposed when saying "Citizen scientists collect more than data. They gather meaning", as (Louv 2012) did. Meanwhile, citizen science is understood in a broad sense. It can be considered as collective action "wherein a variety of contributors invest in (…) providing project support, teaching people how to collect data, collecting data, helping get the word out, conducting research with the data, using data to educate others, making observations using dynamic mapping and visualisation tools, and writing (…) chapters (…) based on the data" (Triezenberg et al. 2012, p. 215). Such activities can also include different spatial levels like local, regional, or global. Furthermore, different time frames are possible, beginning with short term activities and ending up with long term involvement in projects like "BebeR".

Technologies like IT-infrastructures and corresponding devices are relevant drivers for Citizen Science because they provide storage and accessibility of the data sets as well as the computing power to manage the data. Citizen-based resources like computer networks, smart phones and other devices complement existing research IT-infrastructures. All in all, the tools must be managed by a central driver which, in this case, is the university. Examples for the collection of relevant data and occasions concerning climate change are:

- description of soil erosion events, provide historical data
- identification of critical water levels in rivers and possibly related erosion events
- notification of damages occurring as consequence of extreme weather events, e.g. heavy rainfall
- observation and documentation of invasive neophytes along rivers, thus profiting from increased precipitation

There is a debate about accuracy and reliability of data provided by citizens. Only a few projects have a transparent policy about the ownership of the results, and especially volunteers are hardly informed about the intellectual property rights of projects they have been involved (Bonn et al. 2016). As in "BebeR", such problems can be dealt with by the central moderating unit, the university, which seems to be an advantage compared with other project frameworks.

It is furthermore important to evaluate the outcomes of citizen science: From a scientific point of view expected outcomes are innovations and new findings, publications and the creation of new knowledge. From the public side expected outcomes are measures, activities and guidelines, new knowledge and skills as well as appreciation.

2.2.5 Tools to Collaborate Digitally

The aspects presented so far indicate that a multi-party-project such as "BebeR" needs a university as a coordinating unit as shown in Fig. 2 due to different reasons. The overall goal is broad participation of as much actors as possible. As mentioned before, this aim can be supported effectively by using electronic tools and workspaces thus assisting relevant actors to find "new and better ways to engage an interconnected public with new electronic tools for observing, recoding, and reporting" (Louv 2012). However, electronic tools are furthermore helpful to intensify communication, as well as giving actors the opportunity not only to provide data, but to analyze and visualize those. This can be achieved using Internet-based workspaces such as the "BebeR"-website (Pundt et al. 2017). Here, functionalities to foster the communication between project partners are implemented as well as programs that enable users to analyze and visualize spatial data aiming at producing maps which can serve as important decision supporting means. The website, developed and maintained by the moderating university, provides, apart from other functions, the following tools:

(1) *An interactive GIS-based online mapping system:* users can get insight into the environmental and socio-economic situation of the pilot region. They can use basic geographic data and prepared maps, showing adaptation measures. But furthermore, they can generate their "own" maps interactively. Such maps can be

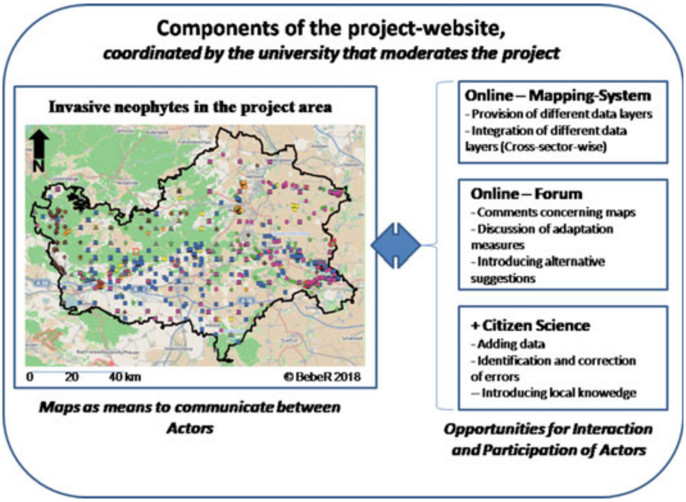

Fig. 4 The website is implemented and coordinated by the university (see Fig. 2), it provides an interactive online mapping system and various opportunities to participate in the development of climate change adaptation measures

published via the project website and be discussed and modified in cooperation with the stakeholders. Citizens can participate in such discussions via a digital forum.

(2) *A discussion forum for citizens and an internal forum for relevant actors and stakeholders:* This allows users to critically review planned adaptation measures and discuss them among all actors. The forum is also important to include the public and guarantee more transparency in view of the future scenarios. Citizens can argue for other solutions or possibly more suitable decisions taking into account that local people sometimes have important knowledge about local conditions which are possibly prone to be ignored by administrational units. Apart from the web based participation tools, both, stakeholders and the public, will be informed using traditional communication instruments like newsletters, workshops, and exhibitions.

Figure 4 presents the basic structure of the "BebeR"-website that is aimed at fostering interactive collaboration. All components have been developed and implemented by the university. For the online mapping system that is usable by all relevant professional participants as well as involved citizens, the provision of data from various sources is essential due to the goal-setting of sustainable adaptation measures. Such measures should take into account as much relevant information as possible to receive a maximum of acceptance among actors.

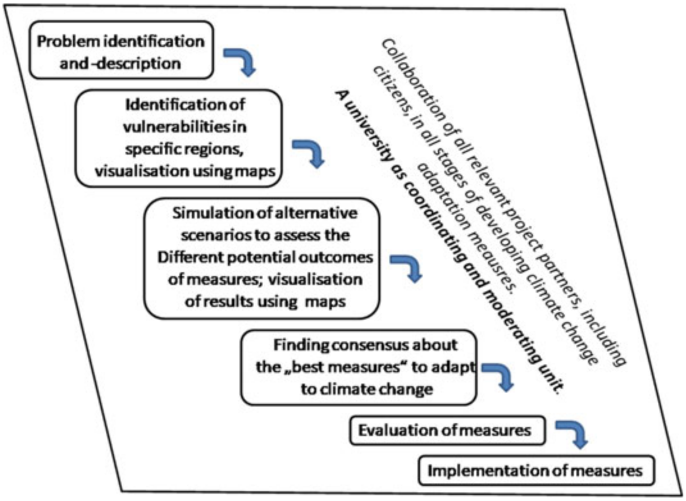

Fig. 5 Steps to develop climate change adaptation measures in a consensual process, coordinated and moderated by a university as an "independent unit"

3 The Outcome: Collaborative Development of Climate Adaptation Measures

Figure 5 illustrates the development of climate change adaptation measures under explicit consideration of inputs of all relevant actors that have access to the "BebeR"-website (Fig. 4). The Mapping system enables project participants to look at or use administrational and other data and maps, to develop new maps or modify existing ones. The forum supports the discussion about the maps and potential measures. This includes the debate about different outcomes concerning the simulation of alternative scenarios, and possibly the selection of "best measures". The inclusion of citizen science approaches may enhance the data- and knowledge base on the one hand, and makes it possible to consider the opinions of local people, which is sometimes very valuable, especially in view of appreciation of planned measures, on the other.

4 Experiences Concerning Restrictions, Limiting Factors and Barriers of Collaboration

A main barrier to achieve the collaboration network as described before has been the establishment of contacts to the *relevant* actors. Instead of the expectations at the beginning of the project it was realized that it depends very much from single persons and their intentions and individual freewill to support a project that is not well established in the usual daily work plan. There are at least two ways to overcome this barrier. One is to contact the superior managers to force the employees to contribute to the projects tasks. However, this way the impression may arise that the new tasks are superimposed and therefore the willingness to carry out the "extra work" is not very high. Within the "BebeR"-project, this approach helped at least in the form that the project goals were communicated in detail to all potentially relevant actors, but finally accepted by the administrational leaders that were invited. This supported significantly to achieve the goal of getting access to the persons in charge. A second pathway to get people into the "project boat" was established through the introductory workshops. They were announced to all potential collaborators from administration, private organizations, enterprises, and other institutions. The answers concerning the first invitation covered a wide range from "not interested" to "enthusiastic". An interesting experience within the "BebeR"-project has been the fact that those who participated in the Kick-off meeting, stayed over a longer period and were interested in the progress of the project. The moderating role of the university, however, was a key feature from our point of view. During the workshops, as well as during the communication between the meetings, various problems arose that had to be tackled in an unbiased way. The goal was to establish adaptation measures that are accepted by all actors. This required clearly finding compromises. To deal with different meanings—and personalities—meant to accept the project situation with its different characteristics, and being disposed to find manageable and sustainable compromises. The Thomas-Kilman Conflict Mode Instrument (TKI) (Thomas and Kilman 2018) indicates different stages of cooperation and involves potential problematic situations even during the communication of various actors. The moderating unit has the task to find solutions if problems occur, and to deal with the problem in a way that is appreciated by all partners. This may be followed by a shift, or avoidance, however, it should be handled in the sense of compromise finding (Fig. 6). Compromising is moderate in both assertiveness and cooperativeness. Consequently, the objective in a multi-actor project must be to find some expedient, mutually acceptable solutions that partially satisfy both parties (Thomas and Kilman 2018). Within BebeR, the moderation of the living lab worked, and works, quite well using elements of the TKI. However, this does not mean that no problems occurred or putative barriers between goal settings of different actors were identified. It is very dependent on the readiness of actors if the will to achieve sustainable results can overweight the barriers. During this process, the coordination and moderation process, which must be based on the balanced consideration of the conflicting viewpoints, is very important.

5 Conclusions

The mitigation of consequences of climate change plays a major role on the regional, and local scale. This initial discovery led to the implementation of a collaborative network of different actors within the project "BebeR". Within this project, the reduction of site-related erosion in small river catchments that are vulnerable to heavy rainfall has been defined as one important goal. To achieve measures to mitigate the poten-

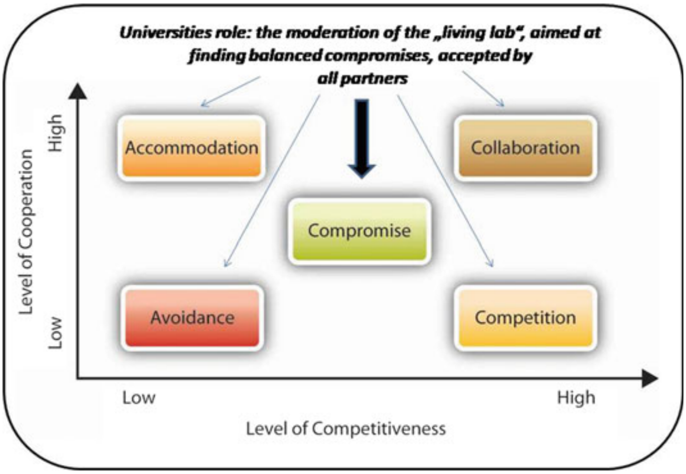

Fig. 6 Multi-actor collaboration involves various factors that may lead to barriers; a moderating instance can help to overcome such limitations (*Source* Bauer and Erdogan 2018, modified)

tial negative consequences of erosion, the different stakeholders from academics, administration, practitioners, organizations, as well as citizens were invited to be part of a collaborative network under guidance of a university. The latter, however, has been appreciated by all partners as competent and foremost independent partner who is able to assess results free from special interests and exclusively based on reliable data and information. So far, the collaborative approach chosen within "BebeR" indicates that the communication requires face-to-face workshops and meetings, as well as effective digital tools. Therefore, the coordinating university implemented a website including an online mapping system and a forum that enables interactive participation of all partners. Especially the mapping system, based on GIS-technologies, has been appreciated by all partners as useful support.

The "BebeR"-project shows that the university, especially in terms of its function as a knowledge broker and facilitator, confirms its role as an anchor institution, a term that was used by Wilson (2012, p. 73f). The university gains important presence in the community and has major impact concerning the communication and collaboration structures. It provides furthermore environmental and IT-knowledge, as well as some cultural benefits to the whole project and beyond. Applying specific moderation methods to overcome conflicts and barriers, as exemplarily discussed in Chapter "The Role of Green Areas in University Campuses: Contribution to SDG 4 and SDG 15", the university also contributes to critical and objective project results and in such a sense it guarantees scientifically sound outcomes.

Just to mention this, concerning the university, the findings and results will have impact on the academic teaching as well as the activities that are related to sustainable development. The idea of "living labs", as it is carried out in the project "BebeR", gives a convenient example and will be stressed more than before in lectures and seminars due to its effectiveness and clear advantages in terms of the integration of theory, methodology and practice.

Last but not least, the projects goals coincide with national policies on environmental impacts of climate change, e.g. the “development of recommendations/action strategies for land cultivation from the perspective of the climate change” (UBA 2016). It shows that universities can play a crucial role to initiate and intensify the dialogue between academics and practitioners in the sense of the so-called 3rd mission. The term has become rapidly popular to refer to a further goal to add to the universities traditional teaching and research missions: the perceived need to engage with societal demands and link the university with its socio-economic context (Univ-Val 2008). Societal demands and socio-economic contexts, as well as environmental requirements, but especially the integration of these different domains, are fundamental aspects of “BebeR”. In such a sense and due to its broad approach, “BebeR” works as a living laboratory. This idea is furthermore supported through the inclusion of citizens which marks an additional step toward improved participation and at least democratization of measures to be implemented to mitigate harmful consequences of climate change.

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The Transformation of Higher Education Institutions Towards Sustainability from a Systemic Perspective

Bror Giesenbauer and Merle Tegeler

Abstract Education for sustainable development has risen in scope and importance during the past decades. Even though the word sustainability has become much of a buzzword, the concept of sustainability itself has not made it to mainstream academia. This chapter presents an analysis of the value systems that shape the course of and the discourse in higher education institutions (HEI). Why are HEIs reluctant to change in general and towards sustainable development in particular? What kind of change would need to occur and which factors drive the evolution of HEIs? These questions are discussed from a systemic point of view against the backdrop of systems theories such as Spiral Dynamics and Integral Theory. Four distinct levels of value systems are described. These value systems represent different evolutions of HEIs that all have their place within the evolution of societies in general. The 17 sustainable development goals (SDGs) are framed as an ideal means for bridging the gap between value system 2.0 and 3.0. Implications for transforming HEIs are discussed. This chapter will be useful to anyone interested in the systemic forces that shape the way how higher education institutions deal with the task of education for sustainable development.

Keywords Sustainable development · Transformation of higher education institutions · Spiral dynamics · Systemic change · Integral theory

1 Introduction

Education for sustainable development has risen in scope and importance during the past decades. The publication of "Our Common Future" in 1987 (World commission on environment and development 1987) coined the term "sustainable development"

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(SD) and gave birth to large collective and global efforts to spread and develop the concept.

As early as 1996 researchers have tried to outline ways of implementing SD as a concept and as a way of thinking at universities (Leal Filho et al. 1996). Since then the body of literature on universities' role in supporting sustainable development has grown and matured, especially in the context of competencies for future challenges (see e.g. Lozano 2006; Leal Filho 2010; Rieckmann 2012; van Weenen 2000; Wiek et al. 2011). Several research groups even have dedicated their whole careers to the case of sustainability.

In September 2015 the United Nations (2015) General Assembly adopted the Agenda 2030 resolution and thus renewed the commitment to SD with the 17 sustainable development goals (SDGs). This framework helps to break down to complexity of SD in more feasible fields of action. Education for sustainable development (ESD) is part of SDG 4: High quality education.

Along these developments the cause of sustainability has gained a lot of attention and a lot of effort has been put into promoting it at higher education institutions (HEIs) (Lozano et al. 2015). And yet—even though the word sustainability has become much of a buzzword—the concept of sustainability itself has not made it to mainstream academia (Thomas 2004; Blanco-Portela et al. 2017). For example, the SDGs are rarely integrated into existing curricula or campus management at German HEIs in spite of the fact that Germany has strong political initiatives for ESD such as the German Council for Sustainable Development of the German Federal Government (*Rat für Nachhaltige Entwicklung*), the German Advisory Council on Global Change *(WGBU*) and the German National Action Plan for ESD (*Nationaler Aktionsplan BNE*) (Müller-Christ et al. 2017, 2018). Furthermore, the term *sustainability* is subject to several misconceptions which hinders the advancement of SD at HEI (Leal Filho 2000).

HEIs compete for research grants, students and prestige—and mostly within the boundaries of mainstream academia. Researchers play by the rules of their respective disciplines and try to make a difference within the limited scope of their niche, too. Success is assessed by publication rates and the amount of research grants and not—for example—by impact on society. Within this numbers driven culture of competition and differentiation there is little space for interdisciplinary topics of general relevance such as SD (Müller-Christ 2017).

This chapter aims to explain the dominance of a competition culture within academia and the subsequent disregard of sustainability issues by analyzing the underlying values systems with systemic frameworks based on Spiral Dynamics (Beck and Cowan 1996). Four distinct developmental stages of value systems are presented and applied to HEIs. Finally, the role of SDGs and learning labs in promoting systemic change is discussed and further implications for change agents are inferred.

2 Evolutionary Stages

The evolution of universities mirrors evolutionary patterns of general societal and human development. There are several theories of development describing these patterns—from pioneers such as Abraham Maslow, Jean Piaget, Jane Loevinger, Susanne Cook-Greuter, Lawrence Kohlberg, Clare W. Graves and others (Wilber 2001). The "emergent, cyclical, double-helix model of adult biopsychosocial systems development" theory of Graves (1981)—an American professor of psychology and colleague of Abraham Maslow—is especially suitable to describe complex change processes and stages of value systems like those of HEIs. After Graves' death in 1986 his theory was refined and introduced to the general public by Don E. Beck and Christopher C. Cowan under the name of "Spiral Dynamics" (Beck and Cowan 1996) and became part of Ken Wilbers integral philosophy (Wilber 2001). This chapter builds heavily on the logic and terminology of Spiral Dynamics and integral philosophy.

Spiral Dynamics describes a distinct sequence of developmental stages of value systems. As civilization turned from hunter-gatherer tribes to more complex forms of social organizations, people's value systems developed along, ideally as a perfect fit with present challenges and environmental conditions. As a general tendency, each stage incorporates several breakthroughs that enabled men to coordinate themselves in networks of ever-increasing size and complexity, from tribes to kingdoms, early nation states, organized world religions, transnational corporations, global markets and the United Nations—to name a few milestones of human coordination. Each stage represents a new way of dealing with arising challenges and simultaneously includes and transcends the preceding stages, preserving and reframing foregoing breakthroughs (Wilber 2001). Furthermore, the stages oscillate between a focus on the collective's and the individual's needs within society, what led Graves to describe human evolution as an upward spiral of outer and inner co-evolution (Beck and Cowan 1996).

In the context of sustainable development at HEIs, the earlier steps of societal coordination—as attributes of worldviews of tribes, empires and the like—are not of interest. Instead, following the reasoning of Hedlund-de Witt (2014a) and Müller-Christ (2017), the focus will be laid upon the four following phases and their respective breakthroughs in organizing people. These breakthroughs are tightly linked to their underlying value systems. According to Hedlund-de Witt (2014b, p. 194) value systems or worldviews are "inescapable, overarching systems of meaning and meaning-making that to a substantial extent inform how humans interpret, enact, and co-create reality".

It is important to note that none of the different worldviews is inherently better, although they might differ in the way they fit conditions (Laloux 2014). Furthermore, even though a society or person might gravitate around a certain worldview, all other worldviews are still to be found in both societies and persons and can still be part of a mature, peaceful and healthy expression of adult human behavior.

In the following the four relevant worldviews are described and linked to sustainability. The four relevant stages are preceded by a short description of the prior worldview to better frame the evolution of worldviews.

2.1 Pre-traditional Worldview: No Sustainability

Early kingdoms and great empires were shaped by a power-focused worldview. Power was often used haphazardly and although there were strict rules, these rules were often changed at a glance (Beck and Cowan 1996). This kind of egocentrism and despotism can still be found in its pure form in organizations such as street gangs, patriarchal organizations and dictatorships. To a lesser extent its basic worldview can still be found in modern organizations and express itself in abuse, in fights over power or in a strong drive for market dominance. This value system is based on a short term, impulsive, hand-to-mouth a thinking and thus has no real understanding of sustainability issues. In fact, this worldview has no problem with abusing natural and social resources. Therefore, it will be disregarded in the discussion of HEI evolution.

2.2 Traditional Worldview: Sustainability 1.0 as Environmental Compliance

The traditional worldview tries to mitigate the fleeting and arbitrary nature of the pre-traditional worldview and is focused on order, absolute truths and standards. This kind of thinking values the group more than its individuals. Its major breakthroughs for humanity are a basic understanding of cause and effect and the ability for long-term planning, supported by strong hierarchies and a strict division of labor (Laloux 2014). These innovations made it possible to build large and lasting organizations. It can be found in its purest form in military organizations and Christian religious institutions, where roles are clearly stated and each individual is thought to be replaceable.

Indeed, the traditional worldview is more focused on establishing stable processes and norms rather than on taking care of nature or people. Organizations and societies that gravitate around the traditional worldview are often quite gruesome to minorities and alternative thinking individuals. Following a fixed set of rules is more important than the rules' content (Beck and Cowan 1996). Therefore, traditional minded organizations are very compliant to regulation—for example with regards to waste management and safe work conditions—and at the same time very reluctant to changing existing rules in favor of sustainable development.

2.3 Modern Worldview: Sustainability 2.0 as Eco-Efficiency

Being dismayed by the strict rules of the traditional worldview, some individuals developed a new, questioning mindset. *What if we changed the rules set generations before us? What if we could make it better?* Questioning assumptions and focusing on optimization marked mighty breakthroughs for society (Laloux 2014). Indeed, modern democracy, technology, empirical science, academic medicine, free market systems were invented from modern worldview and led to the expansion of wealth, citizen rights, knowledge and drastically improved health care. The modern worldview is currently the most powerful worldview in industrialized countries.

However, radically questioning assumptions and striving for evermore optimization did not only create ever-increasing "progress" but also powerful side effects (Scharmer and Kaufer 2013). Breaking with traditions and focusing on efficiency as an end in itself, the modern worldview made the massive exploitation of natural resources possible (Hedlund-de Witt 2014a). Furthermore, the believe in pure meritocracy as well as in the powers of the free market often works against social welfare and the active inclusion of traditionally disadvantaged groups such as people of color and women. In line with this kind of thinking, the modern worldview frames all sustainability issues to be either solvable by eco-efficiency or technological innovation—or to be non-important in the face of economic growth.

2.4 Post-modern Worldview: Sustainability 3.0 as Respect for Nature and People

The post-modern worldview developed as a counter movement to the modern worldview's negative characteristics, namely exploitation of nature and people, cold individualism and an autistic focus on efficiency, achievement and improved numbers. It is described as the green worldview (Beck and Cowan 1996) and focuses on feel-good themes such as respect for nature and people, mutual care-taking, community and wellbeing. The pure post-modern worldview reacts allergically to hierarchy, to society's focus on economy and to the disregard of minorities.

The concept of sustainable development arose from a post-modern worldview, in light of the world's ills and aches. It strengthened the humanitarian role of the United Nations and led to the development of non-governmental organizations (NGOs). Therefore, this worldview is the dominant one of those engaged in the promotion of SD.

However, trying to include all relevant stakeholders in decision making processes free of hierarchy can often be tedious and ineffective. Focused on being positive and empowering, the post-modern way of thinking is often blind to the challenges and trade-offs of implementing sustainability in economic processes—both in industrial and pre-industrial countries (Müller-Christ 2017). Furthermore, the post-modern worldview's language of community and respect is often regarded as "hippie hogwash" and overly political correct by relevant decision making authorities operating from a modern worldview (Müller-Christ and Giesenbauer 2019; Laloux 2014).

2.5 Integral Worldview: Sustainability 4.0 as Systemic Management of Multi-level Development

Whereas the modern worldview focuses on *creating* wealth, the post-modern worldview focuses on *sharing* wealth. Thus, at least in theory, both worldviews could act as partners for enhancing quality of life all over the globe. There are however limits to this cooperation, as both the modern and the post-modern worldview usually take themselves to be the only valid approach to life and therefore often end in opposition.

One of the major breakthroughs of the arising integral worldview is the ability to recognize both the truths and pitfalls of all worldviews and being able use them flexibly in order to create the conditions for sustainable development. This ability to see the world from multiple perspectives simultaneously marks an important milestone in the advancement of human evolution (Brown 2012). Therefore, the integral worldview is described as the first second-tier worldview and the first one with a truly systemic understanding (Wilber 2001).

The integral worldview is closely linked to sustainable development since its focus lies on promoting the health of all systems. Integral thinkers are usually very much aware of their evolutionary purpose and try to create the necessary conditions for the emergence of sustainable change (Laloux 2014; Brown 2012). Trying to support all levels of human evolution to develop concurrently, one step at a time, requires the ability embrace uncertainty and dilemma (Brown 2012). Furthermore, the integral worldview cherishes natural emerging hierarchies based on competency–breaking with both the anti-hierarchy attitude of the post-modern worldview and the deep trust in rigid hierarchies of the traditional and modern worldviews. This means that in integral organizations practically anyone can start initiatives and implement changes—as long as she commits to the case and consults with all relevant stakeholders (Laloux 2014) (Table 1).

3 Four Distinct Value Systems of HEI

Having looked at different stages of evolution and their affinity to sustainable development, it is time to look at higher education institutions (HEIs) in the light of systemic development, following the reasoning of Müller-Christ (2017).

Table 1 Overview of four evolutionary stages

1.0: Traditional Environmental compliance	2.0: Modern Eco-efficiency	3.0: Post-modern Respect for nature and people	4.0: Integral Systemic management of multi-level development
Focused on order, absolute truths and norms Inclined to be critical of development and change	Currently the most powerful worldview in the developed world Based on positivism, focused on achievement	Focused on respect for nature and people Emphasizes ways of knowing beyond the rational-empirical methods of modern science	Embracing uncertainty and able to inhabit different perspectives simultaneously
Basic understanding of cause and effect and the capacity for long-term planning, supported by strong hierarchies and strict division of labor	Radically questioning assumptions and the pursuit of optimization have led to both societal wealth and disastrous side effects for nature and people	The concept of sustainable development emerged from a postmodern world view Emphasis on fundamental changes needed in society as a whole	The integral world view is the first worldview of the second tier and the first with a truly systemic understanding Often holds to an evolutionary, spiritual-unitive notion of development
A set of rules is more important than the content of the rules Particularly critical of material-ist/consumerist notions of development	Belief in pure meritocracy Emphasis on development of science and technology for sustainable solutions Focused on win-win solutions and eco-efficiency	Postmodern thinking focuses on being positive and empowering and is often blind to the challenges and trade-offs of implementing sustainability in economic processes—both in industrial and pre-industrialized countries	Emphasis on integration and synthesis of different interests and perspectives Attempts to integrate local and global Potential willingness for change of lifestyle and of self

Based on Müller-Christ (2017) and Hedlund-de Witt (2014a)

3.1 *Traditional HEI 1.0: Preserving Truths and Insights from Experts*

Universities—as preservers of truths, virtues and norms–were invented from a traditional worldview and have managed to keep their distinctive spirit for several centuries. Even in the 20th century, teaching at universities often meant that a supposedly all-knowing professor literally read his insights and knowledge to the passive students. This kind of worldview is not open to crosscutting topics such as sustainable development (except in very concrete forms such as the protection of rare plants and animals) and rather protects the division of disciplines (ibid.).

Although most HEIs to this date are not pure traditionalist, their basic structure is usually still shaped by traditional thinking. The more they gravitate around the traditional worldview the less they are open to impulses from the outside, resulting in few initiatives for SD that go beyond the bare minimum of compliance with environmental or minority protecting regulations.

3.2 Modern HEI 2.0: Top Notch Science in Specialized Fields

Current academia is mostly shaped by the modern worldview with its focus on quantitative success, professional specialization and competition. This kind of worldview leads to an academic merit system based on numbers such as frequency of publications, journals' impact factor and level, acquired research grants or number of students, to name a few. Each HEI and each participant of the scientific community thus compete for attention, grants and status (Müller-Christ 2017). Researchers have to distinguish themselves by both quality, quantity and specialization of publications, as defined by their narrow disciplinary niche. This means that crosscutting topics such as SD are often disregarded—not so much due to their content but due to their limited ability to promote careers.

Furthermore, in the field of campus management, the modern worldview of HEI 2.0 leads to optimized and numbers-driven administration, with clear and at the same time changeable processes. Sustainability is generally not a part of HEI 2.0's reasoning, with the exception of "greening the campus" and eco-efficiency regarding the use of water, energy and other resources, leading to reductions of costs (Leal Filho 2010). Although being cost-aware and optimizing processes are highly appreciated from a SD point of view, HEIs 2.0 are too much focused on quantitative success and show a lack of societal responsibility. According to Müller-Christ (2017), this stage can be classified as an egocentric system.

3.3 Post-modern HEI 3.0: Action Research and Stakeholder Dialogue

When members of HEIs act mainly from a post-modern worldview, they tend to have a different approach to teaching and researching. Being highly aware of global challenges and societal responsibility they try to integrate different perspectives of regional and global stakeholders (Leal Filho 2010). They try to make everyone heard, especially with regards to students, minorities and disempowered and underprivileged groups (see e.g. the Rio+20 Treaty on Higher Education 2014). This is reflected by the large amount of qualitative research methodologies and inter- and transdisciplinary research projects. The HEIs' ethos thus changes from fact orientation to relationship orientation.

In teaching, HEI 3.0 prefer dialogue oriented seminars to classic large-scale lectures and experiment with innovative concepts such as global classrooms. These learning arrangements aim at competencies rather than knowledge only (Rieckmann 2012) and try to bridge the gaps between the scattered disciplines and stakeholders by reaching out and promoting self-reflection. Moreover, post-modern universities begin to experiment with online learning tools and on-demand lectures to further help meeting students' needs.

In the field of campus management, HEI 3.0's post-modern worldview is reflected by the attempt to achieve climate neutrality and reduce unnecessary resource consumption. Furthermore, in line with their dialogue orientation, HEI 3.0 are often shaped by student initiatives, for example regarding organic, vegan and/or vegetarian food options as well as social initiatives regarding inclusion, gender sensibility or refugee projects. In general, HEIs 3.0 try to be as much stakeholder oriented and considerate as possible.

A lot of current researchers—especially in the realm of sustainability research—are centered in the post-modern worldview of HEI 3.0. However, to advance or stabilize their careers they often have to play by the rules of the modern worldview of HEI 2.0, leading to a lot of tension and trade-offs on a personal level.

3.4 Integral HEI 4.0: Integrated Learning Labs

While there are several examples of integral organizations in business (Laloux 2014) there are few examples for integral HEIs. Deduced from Laloux' (ibid.) research, such HEI 4.0 should possess qualities of self-management, a strive for wholeness and listen to their evolutionary purpose. Researchers are then part of a larger evolution and generation of knowledge, blurring the boundaries between objects and subjects of knowledge as well as between rational and non-rational sources of knowing (Müller-Christ 2017; Brown 2012).

Researchers, teachers, students and citizens are then co-creating solutions for common challenges. Therefore, a HEI 4.0 can be framed as a citizens' university (*Bürgeruniversität*) (Schneidewind 2014). Integral HEIs build on post-modern HEIs' community values but go beyond them by allowing natural hierarchies to emerge and by allowing the open discussion of tensions, dilemma and trade-offs of sustainable development. These developments are facilitated by the willingness of individuals to take responsibility for SD challenges and be vulnerable at the same time—a new kind of action oriented mindfulness. Therefore, within their Theory-U model, Scharmer and Kaufer (2013) propose the evolution from HEI 1.0 to HEI 4.0 to be an *inversion journey*: "That means opening the mind, heart, and will (micro), moving conversations from downloading to generative dialogue (meso), and converting hierarchical

Table 2 Four phases of HEI evolution

Evolutionary phase	Teaching	Research	Operation
HEI 1.0 Traditional system, hierarchical	The scientist reads his books	Confirmation of dogmas Structure of disciplines	Building palaces of knowledge
HEI 2.0 Modern system, competitive, egocentric	Result-oriented transfer of non-reflexive knowledge Construction of project-oriented learning	Rationalization knowledge generation Staged interdisciplinarity Analytical problem orientation	Rapid growth in functional buildings without energy awareness Control of cash flows
HEI 3.0 Post-modern system, dialogue-oriented	Competencies-oriented transfer of self-reflective knowledge	Transdisciplinarity Solution orientation through new forms of dialogue Action research	HEIs as a place for encounters Virtual spaces for learning and dialogue Climate neutrality
HEI 4.0 Integral system, co-creative	Intentional generation of self-transcending knowledge Co-creative design	Using collective creativity Global action research HEI	Sources of physical and creative energy for the whole environment

Based on Müller-Christ (2017)

silos into eco-creative fields that connect the eco-system as a living whole (macro)" (ibid., p. 240).

Scharmer and Kaufer (2013) further propose that learning at integral HEIs will be shaped by global classrooms, action learning, innovation hubs and individualized lifelong learning journeys. Sustainable development will then be integrated into the DNA of HEI, not as a special topic but as the main purpose and driver of social learning. Ideally this would lead to true trans-disciplinary and trans-institutional action research aimed at solving our most pressing societal problems. This evolution of HEIs will likely not lead to a frictionless organization but produce its own unforeseen problems (Table 2).

4 Facilitating the Evolution of HEI

HEI 4.0 will most likely be needed to solve humanities problems. However, most universities are at the point of trying to perfect HEI 2.0, in line with the general societal evolution. Van Opstal and Hugé (2013, p. 697) comment:

> Despite claims of a paradigm shift, scientists argue that the widely institutionalized SD paradigm—as endorsed by many U.N. documents—remains based on a modern normal scientific and classical economic rationality, incorporating dominance of some worldviews

instead of thorough integration of different views with variety serving as a basis for sustainability.

This call for advancement of all evolutionary levels of HEIs is also reflected in the Rio+20 Treaty on Higher Education (2014): "To be transformative, higher education must transform itself." In line with these comments, the following paragraphs are intended to show ways of facilitating the evolution of HEIs toward a post-modern or even integral level.

4.1 SDGs: Bridging the Gap Between 2.0 and 3.0

In order to make the change from one evolutionary phase to the next, there need to be either radical shifts in consciousness and structure or—following a gentler path—bridges toward the new paradigm (Beck and Cowan 1996). The sustainable development goals (SDGs) adopted by the General Assembly of the United Nations (2015) appear to be an ideal means to bridge the gap between HEI 2.0 and 3.0.

First of all, the SDGs are—as their name clearly states—goals and are thus well suited for the numbers and achievement driven modern worldview of HEI 2.0. Their content, however, is one of respect for nature and people and therefore promotes the emergence of the post-modern and integral worldviews. Secondly, the structure of the SDGs helps to break down the complex challenge of SD and enables the integration of SD into specific disciplines. The focus on high quality education of SDG 4 further helps to connect SD to the realm of HEIs.

Moreover, the concept of the SDGs is not limited to scattered research and teaching of singular disciplines—the framework itself references the overarching goal of a more general SD. Thus, by implementing a single SDG, the door is open to connect it to one or more of the other SDGs and to come closer to the "transformation of higher education itself".

Indeed, the SDG framework as a whole stresses the importance of sometimes contradictory goals. Embracing contradictions and tensions is closely linked to the emergence of the integral worldview seeing the relative truth of multiple perspectives. For example, economic growth and decent work (SDG 8) can lead to immense progress in issues of social sustainability such as ending poverty (SDG 1) health (SDG 3) or quality education (SDG 4), to name a few, and at the same time be detrimental to other goals such as climate action (SDG 13) and life below water and life on land (SDG 14 and 15). These tensions are not easily solved and need to be balanced by individuals and institutions that are able to integrate different perspectives without losing the ability to act. Working with the SDG framework as a whole might therefore promote the development toward integral HEI 4.0. As Singer-Brodowsky and Mader (2018) state, to enable complex changes such as the *Energiewende* (energy transition) a change of the education system is needed as well.

4.2 Learning Labs and Innovation Hubs

While the SDGs are helpful to promote the evolution of HEIs by their content and structure alone, teaching methodologies need to be adjusted, too. To promote the development of competencies for future challenges, teaching needs to guide students toward self-directed and research-based learning. Learning labs might at first be closely linked to classic 2.0 research and yet open up the formerly linear transfer of knowledge, thus enabling the emergence of post-modern and integral problem solvers.

If overcoming the challenges of SD implies transforming HEIs themselves, then learning labs are a helpful means to reach this ambitious goal. In the beginning, labs might be more conservative and be formed by students and teaching staff only, but over time this arrangement might involve more and more stakeholders relevant to the issues at hand. In the end this might lead to inter- and transdisciplinary innovation hubs, where different stakeholders work together to design innovative solutions for complex challenges (Scharmer and Kaufer 2013; see e.g. Armstrong et al. 2014).

4.3 Leadership Qualities

To shift toward HEI 4.0 a whole institution approach is needed (Mader and Rammel 2015) which implies an integrative leadership concept. Therefore, in line with the assumptions made by Scharmer and Kaufer (2013), building collective leadership capacities is crucial for the transformation of HEIs. Scharmer and Kaufer (2013, p. 243) propose the need for awareness-based leadership technologies:

> The capacity to facilitate processes of profound societal innovation is grounded in mindful leadership and awareness-based leadership technologies that link the intelligences of head, heart, and hand. These methodologies combine state-of-the-art organizational learning tools with participatory innovation techniques and blend them with awareness-based leadership practices.

Following the reasoning of Beck and Cowan (1996), HEIs have to shift from 2.0 toward 4.0 one step at a time without skipping intermediate steps. Therefore, leadership quality in general has to be raised at HEIs before more advanced techniques can be applied. At the beginning this might imply the need to strengthen the positive breakthroughs of the modern worldview, namely process optimization, efficiency and questioning assumptions, in order to prepare the ground for healthy and sustainable evolution of HEIs. Furthermore, HEIs should at the same time shift toward a dialogue- and stakeholder orientation and include more reflective and active learning arrangements to facilitate the emergence of HEI 3.0 and to minimize the negative impact of the still dominating modern worldview.

5 Conclusion

Although the different worldviews have been presented separately throughout this chapter, all of them can—to some extent—be found within a single institution simultaneously. Therefore, the transformation of a HEI would probably be tackled most effectively by a multi-level organizational development approach from an integral point of view, depending on the evolutionary level of HEIs' leaders. The chapter at hand tries to contribute to the evolution of more complex approaches to leadership and transformation.

In order to promote the transformation from HEI 2.0 over 3.0 toward 4.0, championing the inclusion of SDGs into curricula would be a vital first step. The focus on goals is very much in alignment with HEI 2.0's achievement focused worldview. At the same time, the goals' content prepares the ground for a shift towards HEI 3.0 and HEI 4.0. The SDGs could, however, also be used as a means for greenwashing the campus—especially when minor initiatives are used to bloat the HEIs contribution to the SDGs. But if the SDG framework is taken seriously, it could as well serve as a map of the SD landscape and thus help exploring the terrain.

Moreover, learning labs and innovation hubs would further facilitate the evolution of more complex forms of academic and societal collaboration to overcome the planets' most pressing problems. This shift is of huge importance for our common future, as higher education institutions have a high impact on the thinking and competencies of future leaders. Therefore, the transformation of HEIs sets the foundation for the transformation of society in general.

If HEIs are to live up to their potential and responsibility for the planet, collective efforts have to be undertaken, e.g. by promoting the SDGs, learning labs and systemic thinking at every educational level. However, further research and systemic concepts are needed to help HEIs and their members to successfully transform themselves.

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TEAM Sustainability—The Contribution of Science to the Management of Governments' Sustainability Advisory Councils

Dorothea Schostok

Abstract The development of a sustainability strategy in accordance with the good governance criteria includes, among other aspects, the reflexive development of the sustainability strategy which is understood as the continuous questioning of decisions in a horizontal and vertical multi-level system. In this context, the involvement of non-state actors in sustainability management is a central aspect addressed by the good governance criterion of participation. This paper analyses the sustainability management and deepens the sustainability architecture in Germany and its federal states. A special emphasis is given to the governments' sustainability advisory boards, which could unite non-state actors. Science can play a central role: Firstly, in pro-active participation and secondly as the organiser of these sustainability advisory boards. The latter has many advantages for both governmental and non-governmental actors as this paper points out. Methodologically, the presentation is based on a desktop research, which was extended by an impact analysis of the "TEAM Sustainability" as a part of the analysis of the sustainability architecture of the state of NRW. The presentation will be useful for all state actors involved in the further development of their sustainability architecture. Non-state actors, especially the scientific community, can also profit from the findings to strengthen their role in governmental sustainability advisory boards.

Keywords Sustainability advisory council · Sustainability strategy · Sustainability architecture · Participation · Non-state actors

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1 Introduction

In line with the pluralistic definition of the management concept in economics,[1] sustainability management can be considered from three central perspectives: a personal-institutional, a functional and a factual perspective. The functional perspective addresses classic sustainability management, which includes for example management rules, controlling instruments and sustainability reporting. The personal-institutional perspective—also referred to as sustainability architecture—regulates the existence and interaction of decision-making, advisory and participation bodies. The factual perspective is aimed at the question "What can be managed?" In terms of content, it refers to fields of action, crosscutting themes and focal topics and thus to the Sustainable Development Goals (SDGs). The following illustration visualises the three perspectives of sustainability management and classifies the sustainability advisory boards (Fig. 1).

This article refers to the personal-institutional perspective (sustainability architecture) and focuses on the analysis of decision-making, advisory and participation bodies. Emphasis is put on the involvement and participation of non-state actors as it is given a central place in the criteria of good governance with regard to sustainability strategies ("Good Governance") (Steurer 2010, p. 37; ESDN, n.d., UNDESA 2002). Already the United Nations Conference on Environment and Development on Agenda 21, which took place in Rio de Janeiro in 1992, emphasised the importance and necessity of National Sustainable Development Strategies (NSDS) and their development "through the widest possible participation" (UN 1992, Chap. 8.7). "A

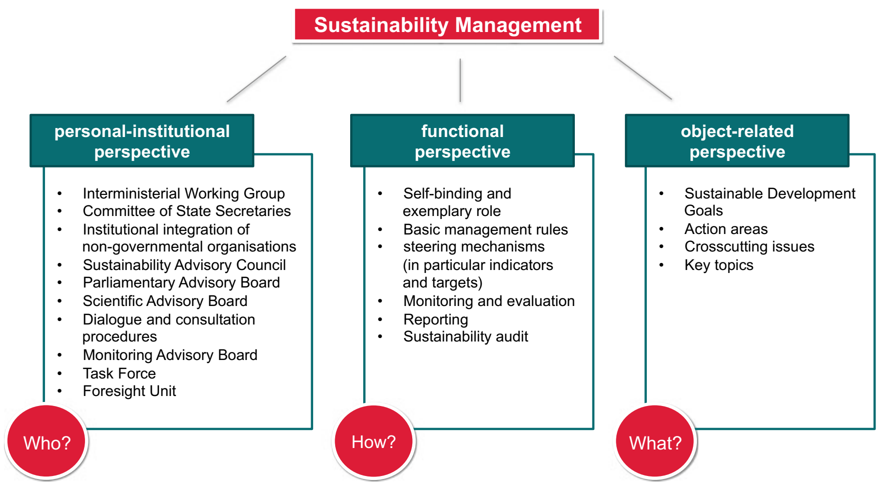

Fig. 1 Three perspectives of sustainability management. *Source* Schostok (2017, p. 6)

[1] See, for example, Becker (2011, pp. 24–29), Tanţău/Bock (2010, p. 9ff.), Steinmann/Schreyögg (2005, p. 6f.).

sustainable development strategy is a tool for informed decision-making that provides a framework for systematic thought across sectors and territory. It also helps to institutionalize processes for consultation, negotiation, mediation and consensus building on priority societal issues where interests differ" (UNDESA 2002, p. 9).

The aim of this article is to draw on the insights gained from the management of the TEAM Sustainability, which indirectly functions as the Sustainability Advisory Council of the federal state of North Rhine-Westphalia. Therefore, this paper discusses selected sustainability architectures of the federal and state level of Germany and presents the lessons-learned made during the coordination and organisation of the TEAM Sustainability.

2 Background

2.1 Sustainability Strategy of North Rhine-Westphalia

The federal state of North Rhine-Westphalia (NRW) has a highly energy- and resource-intensive economic structure and is one of the most important regions for the entire Federal Republic of Germany and within Europe. The state of NRW is the most densely populated area (515 inhabitants per km^2) in Germany and with about 17.6 million inhabitants (22% of the German population) one of the most important urban areas in Europe (Federal Statistical Office 2014). The state of NRW is a national and international important economic region: 21.9% (625 billion euro) of German GDP were generated in NRW in 2013, these are 4.6% of European GDP (EU-28) (NRW.INVEST, n.d.). A total of 15.9% of Germany's export goods are produced in NRW—this results in an export value of 180.6 billion euros in 2014 (ibid.). North Rhine-Westphalia industry accounts for 28% of German net electricity consumption and emits 18.6% of industrial greenhouse gas emissions (GHG) in Germany (IWR, n.d.), (MKULNV NRW 2014). This overview of key facts makes clear that the federal state of NRW has to take on a high degree of responsibility for sustainable development and at the same time can make a significant contribution to achieving the Sustainable Development Goals (SDGs).

The state government of NRW decided in a cabinet approval from November 2013 to develop a sustainability strategy for the federal state of North Rhine-Westphalia (NRW) (MKULNV NRW 2013). In June 2016, the state government of NRW adopted the first sustainability strategy for NRW (State Government NRW 2016a, b), which covers all three dimensions of sustainability (environmental, social, economic). Beside the strategy, that is also available in English (State Government NRW 2016c), a central pillar of the sustainability strategy for NRW is a target and indicator system consisting of roughly 70 indicators with targets for the years 2020, 2030 or 2050 responding to 19 central areas of action in the sustainability strategy (State Government NRW 2016a, b). All indicators are aligned to the United Nations

Agenda 2030 (UN 2015) and the state of NRW was the first state in Germany that has committed itself to implementing the SDGs.

In the cabinet approval was listed that the sustainable strategy should be developed with the participation of all other state ministries, the state government and in exchange with stakeholders from civil society, economy, municipalities and science (MKULNV NRW 2013). As a result, several cooperation and participation elements were established within the process of developing the sustainability strategy: an inter-ministerial working group "IMAG Sustainability", annual sustainability conferences, two public consultation rounds and accompanying projects: a project on the "Successful Development of Sustainability Strategies" by the Bertelsmann Foundation,[2] participation projects by the Local Agenda 21 NRW[3] and two accompanying research projects by the Wuppertal Institute for Climate, Environment and Energy.

2.2 *Accompanying Research Projects by the Wuppertal Institute for Climate, Environment and Energy*

This paper is based on the partial results of the completed scientific project "Sustainability Strategy for North Rhine-Westphalia (NRW)—Conceptual Analyses and Considerations on Designing a Sustainability Strategy NRW from the Science Perspective" (2013–2017)[4] and the on-going scientific project "Experiences of Implementing Statewide Sustainability Strategies—Case Study: Sustainability Strategy NRW" (2016–2020).[5] Based on the example of North Rhine-Westphalia, the second research project aims at exploring selected questions that typically arise during the implementation of a statewide sustainability strategy.

The "TEAM Sustainability" serves as an advisory, discursive accompaniment of the scientific projects of the Wuppertal Institute addressing the Sustainable Strategy of NRW and thus indirectly the development and implementation of a sustainability strategy NRW from the stakeholder perspective by means of open, internal discussions (Wuppertal Institute 2013, 2016).

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[2]Project description: https://www.bertelsmann-Foundation.de/de/unsere-projekte/abgeschlossene-projekte/nachhaltigkeitsstrategien-erfolgreich-entwickeln/.

[3]Project description: https://www.lag21.de/projekte/details/netzwerk-nachhaltigkeit/.

[4]Project description: https://wupperinst.org/en/p/wi/p/s/pd/469/. Funded by the Ministry for Climate Protection, Environment, Agriculture, Nature and Consumer Protection of North Rhine-Westphalia.

[5]Project description: https://wupperinst.org/en/p/wi/p/s/pd/650/. Funded by the Ministry for Environment, Agriculture, Conservation and Consumer Protection of the State of North Rhine-Westphalia.

3 Sustainability Architecture of the Federal Republic of Germany and Selected Federal States

A sustainability architecture can consist of very different elements, e.g. an inter-ministerial working group, a committee of state secretaries, a parliamentary advisory board, an institutional integration of non-governmental organistions, a sustainability advisory council, a scientific advisory board, a monitoring advisory board, a foresight unit and/or task force. Table 1 provides an overview of the most frequent elements in Germany and the federal states supplemented by information on accompanying projects, as well as dialogue and consultation procedures for and of non-state actors.

The advisory councils with participation of non-governmental members are deepened in this chapter for the national and state levels. At the level of the federal states, of the twelve federal states that have published a sustainability strategy, four have a sustainability advisory council with the participation of non-governmental members. In the following, the national sustainability architecture and subsequently the four sustainability architectures of the federal states of Baden-Wuerttemberg, Hesse, Lower Saxony, Saarland and Thuringia are examined in more detail. The sustainability architecture of the state of North Rhine-Westphalia is presented and the novel "Third Party" approach of the TEAM Sustainability is presented.

3.1 Federal Republic of Germany

The sustainability architecture of the Federal Republic of Germany is based on a multi-level system. The three central bodies are the Committee of State Secretaries for Sustainable Development, the Parliamentary Advisory Board for Sustainable Development and the Council for Sustainable Development. The Council for Sustainable Development (RNE), convened by the Federal Government in April 2001, consists of 15 non-state actors in public life. The members of the Council will be appointed ad personam (and not as formal representatives of individual interests or associations) by the Federal Chancellor personally for three years; the last appointment took place on 28 October 2016 (Federal Government of Germany 2016, p. 26, 30), (German Council for Sustainable Development, n.d.). "The German Council for Sustainable Development (…) is subject solely to the mandate based on the decision adopted by the German Government to establish the Council. It is independent in its activities" (German Council for Sustainable Development 2016, S. 1). The tasks of the Council for Sustainable Development are: To develop contributions for the implementation of the national sustainability strategy, to identify concrete fields of action and projects and to make sustainability an important public concern. The council regularly publishes products: Statements and recommendations on national and international sustainability policy, topic-specific advice and proposals as well as monitoring reports (peer reviews) on the German Sustainability Strategy. If necessary, the Council also involves external experts to carry out analyses and studies so that the national sustainability strategy is also supported through accompanying projects (German Council for Sustainable Development, n.d.).

Table 1 Overview of existing sustainability architectural elements, as of January 2018

	Sustainability strategy	Inter-ministerial working group	Parliamentary advisory board	Sustainability advisory council with participation of Non-governmental organisa-tions/actors	Accompanying project	Dialogue and consultation process
Federal Republic of Germany	✓	✓ Committee of State Secretaries	✓	✓	(✓) via German Council for Sustainable Development	✔
Baden-Wuerttemberg	✔	✔		✔	✔	✔
Bavaria	✔	✔				✔
Berlin		✔				
Brandenburg	✔	✔			✔	✔
Bremen						
Hamburg				✔	✔	
Hesse	✔	✔		✔	✔	✔
Mecklenburg Western Pomerania						
North Rhine-Westphalia	✔	✔		(✔) TEAM Sus-tainability	✔	✔
Lower Saxony	✔	✔		✔		✔
Rhineland Palatinate	✔	✔				✔
Saarland	✔	✔		✔		✔
Saxony	✔	✔				✔
Saxony-Anhalt	✔	✔				✔
Schleswig Holstein	✔	✔				✔
Thuringia	✔	✔	✔	✔	✔	✔

3.2 State of Baden-Wuerttemberg

The Sustainability Advisory Council is the advisory body of the state government on all questions of sustainable development in Baden-Wuerttemberg. In total, 40 representatives from all areas of the economy, science and society, including the heads of associations and institutions of the environment, agriculture, economy, trade unions, local authorities, youth, women, integration, social affairs and churches are members of the Sustainability Advisory Council. Medium-sized and large companies are represented on the Sustainability Advisory Council by their entrepreneurial personalities. The Youth Advisory Board of the Sustainability Strategy is also represented by a member of the Sustainability Advisory Council. The task of the Sustainability Advisory Council is to provide stimuli for the sustainable development of the country and to draw up recommendations in this regard. The Sustainability Advisory Council was constituted on the 6th of October 2012 and meets twice a year since 2013. In addition to the advisory board meetings, topic-specific working groups can be convened under the leadership of the respective ministries, which deal with selected topics more intensively in between the advisory board meetings. The following four working groups currently exist: Education for Sustainable Development, Energy and Climate, Goals and Indicators, Sustainable Mobility. The overall organisation of the sustainability strategy of the state of Baden-Wuerttemberg is in the responsibility of the Head Office that is located at the Ministry of the Environment, Climate and Energy Industry of Baden-Wuerttemberg. The Head Office supports the state government strategically and conceptually in the implementation of the sustainability strategy (Head Office Sustainability Strategy Baden-Wuerttemberg, n.d. a–f).

3.3 State of Hesse

The highest decision-making body in the Hesse sustainability strategy is the "Sustainability Conference". In this Sustainability Advisory Council, 49 members from politics, economics, science, administration and society discuss the focal topics and direction of the strategy. In addition, goals for further work are defined in the plenum and concrete activities such as the establishment of a steering committee for a new priority topic, are decided upon. Since the first Sustainability Conference in October 2008, the committee has met at regular, mostly annual, intervals chaired by the Prime Minister of Hesse and the Minister of the Environment of Hesse. In addition to the Sustainability Conference, the central bodies of the sustainability architecture of the State of Hesse consist of task force Goals and Indicators, steering committees and an administrative office.

The task force consists of representatives of economic, environmental, consumer and social associations as well as science and ministries and is headed by the President of the Hesse State Statistical Office. The main tasks of the task force are to provide technical advice on objectives, indicators and target values, to discuss the results of the progress reports and to prepare the basis for decisions at the Sustainability Conference. In addition, expert groups can be convened for very specific questions on indicators and target values in which members of the task force can also participate. The steering committees are responsible for the concrete design of the focal topics decided upon by the Sustainability Conference and subsequently support the implementation of the measures and activities initiated. The members consist of institutions of the Sustainability Conference, youth representatives and appointed experts. The four steering groups currently exist: Biological diversity, Sustainable consumption, Climate protection and climate change adaptation. The steering groups initially form working groups, which then focus on specific sub-themes. The Head Office, which is located at the Ministry of the Environment, Climate Protection, Agriculture and Consumer Protection of the State of Hesse, coordinates and accompanies the sub-processes. In doing so, the Head Office wants to ensure that the Sustainability Strategy of the federal state of Hesse links existing activities with each other, exploits synergies and remains compatible with the European and national strategies (Hessian Ministry for the Environment, Climate Protection, Agriculture and Consumer Protection, n.d. a–e).

3.4 State of Lower Saxony

The State of Lower Saxony has appointed experts from the fields of politics, business, science and research, education and the arts for the Lower Saxony Council for Sustainability. The Sustainability Advisory Board comprises a total of 11 personalities. Founded in autumn 2017, the committee is to advise the state government on all sustainability issues and provide impetus for initiatives and actions. The triad of ecological, economic and socio-social sustainability is to be considered (State Government Lower Saxony 2017).

Since no freely available information on the structure and institutionalisation of the Sustainability Advisory Council in the sustainability architecture of the State of Lower Saxony is yet available, this Advisory Council is not considered more extensively at this point.

3.5 State of Saarland

Saarland is the only federal state in Germany that has enshrined the establishment of a Sustainability Advisory Council with the participation of non-governmental members in a law: According to Sect. 44 of the Saarland Nature Conservation Act as amended on October 28th 2008, an independent Council for Sustainability is formed in each parliamentary term to advise the state government on questions of sustainability policy. The § 44 SNG also stipulates from which organisations and institutions representatives are to be sent to the Council for Sustainability. In addition to the eleven organisations under § 44 SNG, two representatives of the Saarland Youth Council are assisted in an advisory capacity. The management of the Sustainability Advisory Council is in the responsibility of the supreme nature conservation authority. To coordinate sustainability activities, the state government has set up a Head Office at the Ministry of the Environment and Consumer Protection (Saarland Government 2017, p. 64), (Saarland—Ministry for the Environment and Consumer Protection, n.d.).

3.6 State of Thuringia

The sustainability architecture of the federal state of Thuringia is essentially based on the three committees: State Secretary Working Group, Sustainability Advisory Council, Parliamentary Advisory Board, the latter was set up in 2017. The Sustainability Advisory Council was founded in 2008 on the recommendation of the State Parliament of Thuringia and is appointed by the Prime Minister of the Free State of Thuringia. In the current third appointment period, the Sustainability Advisory Council is made up of 15 actors. The work of the Sustainability Advisory Council is supported by a Head Office that is located at the Thuringia Ministry for Environment, Energy and Nature Conservation. The Sustainability Advisory Council´s central tasks include advising the Thuringia state government on an ecologically, economically and socially balanced policy and participating in the continuation of the Thuringia sustainability strategy and its evaluation (Free State of Thuringia 2012, p. 9), (Head Office of the Advisory Council on Sustainable Development Thuringia, n.d.), German Council for Sustainable Development 2009).

4 Sustainability Architecture of the Federal State of North Rhine-Westphalia

The sustainability architecture of the state of North Rhine-Westphalia for developing and implementing the NRW sustainability strategy consists of an inter-ministerial working group "IMAG Sustainability Strategy", dialogue and consultation procedures and three accompanying projects. With the interdisciplinary approach, which follows an integrative perspective on the three dimensions of sustainability, the accompanying projects and in particular their committees for the integration of non-state actors are a central component of the sustainability architecture of the state of NRW even though they have not been directly convened by the NRW state government. The following figure systematises the elements of the NRW sustainability architecture and their interaction (Fig. 2).

The inter-ministerial working group "IMAG Sustainability Strategy", established in 2013, coordinates the implementation of the sustainability strategy under the chair-

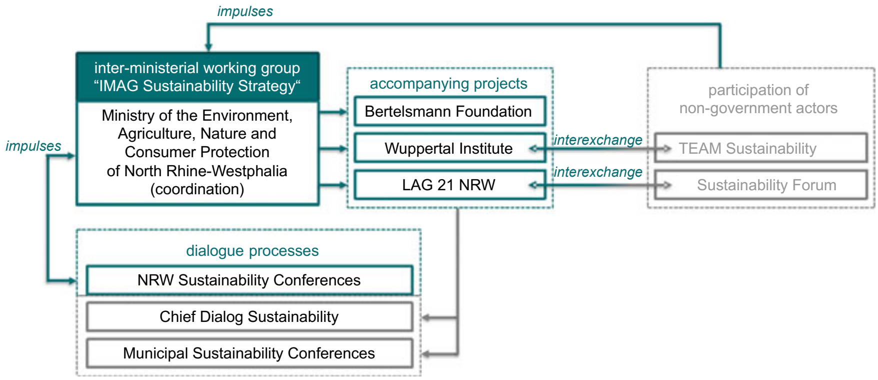

Fig. 2 Sustainability Architecture of the State of North Rhine-Westphalia (Accompanying projects carried out by the Bertelsmann Foundation include the project "Successfully developing sustainability strategies" and the project "Monitor Nachhaltige Kommune". The first project identified best practices and success factors for the development of sustainability strategies in Germany and abroad from 2013 to 2015 and selected best practices were applied to the state of North Rhine-Westphalia as examples (see e.g. Bertelsmann Foundation 2014, 2015a, b, c, d; Borbonus et al. 2014, 2015a, b; Jacob et al. 2014, 2015). The "Monitor Sustainable Community" project launched in 2015 focuses on raising awareness and supporting responsible actors in local politics and administration of the advantages of active and impact-oriented management of sustainable development. (MULNV NRW, n.d. a) Since the procedural and institutional participation of non-governmental organisations in the development and implementation of NRW's sustainability strategy is not the focus of these two projects, reference is made here to the Bertelsmann Foundation (n.d. a, b) for comprehensive information.)

manship of the Ministry of the Environment, Agriculture, Nature and Consumer Protection of North Rhine-Westphalia and with the participation of all departments and prepares a draft progress report. Implementation and financing of the sustainability strategy are the responsibility of the ministers and their departments concerned within the framework of the funds made available by the budgetary legislator (State Government NRW 2016, p. 56).

In addition to two public consultation rounds, which were conducted during the development phase of the sustainability strategy, the Ministry for the Environment, Agriculture, Nature Conservation and Consumer Protection of the State of North Rhine-Westphalia is inviting to the "NRW Sustainability Conference".[6] It is an interdisciplinary exchange platform on future issues of the state of North Rhine-Westphalia and has been held annually since 2012. Around 400 actors from civil society, local authorities, business and science from all over the country take part in the annual NRW Sustainability Conferences (MULNV NRW, n.d. b, c). The NRW Sustainability Conferences are also the central exchange and communication platforms for the implementation of NRW's sustainability strategy.

[6] A detailed documentation of the NRW Sustainability Conferences is available on the website http://www.nrw-nachhaltigkeitstagung.de/.

The accompanying projects, which are supported by the Ministry for Environment, Agriculture, Nature Conservation and Consumer Protection of North Rhine-Westphalia[7] for the development and implementation of the sustainability strategy, are carried out by the Bertelsmann Foundation, the State Working Group Agenda 21 NRW e. V. (LAG 21 NRW) and the Wuppertal Institute for Climate, Environment and Energy. Since this paper refers to the personal-institutional perspective of sustainability management and in particular to sustainability architecture and thus focuses on the analysis of decision-making, advisory and participation bodies and especially the participation of non-state actors, only the relevant sections of the accompanying projects are examined in more detail below. For further information please refer to the websites of the individual institutions.

The NRW state government has not convened its own direct Sustainability Advisory Board to develop and implement NRW's sustainability strategy. Nevertheless, the external projects accompanying the NRW sustainability strategy have many committees with the participation of non-governmental members which are summarised below.

With the accompanying project "Network Sustainability NRW" LAG 21 NRW makes an important contribution to supporting the sustainability processes in NRW by expanding and consolidating the network formats with the involvement of state and non-state actors. The central network formats include the "Sustainability Forum NRW", the "Chief Dialogue? Sustainability" and the "Municipal Sustainability Conference".[8] The Sustainability Forum NRW, which is supported by more than 20 civil society organisations and coordinated by LAG 21 NRW, focuses on professional cooperation and joint civil society positioning vis-à-vis the state government of NRW (LAG 21 NRW, n.d.).

With the start of the accompanying research project "Conceptual Analyses and Considerations for the Design of a Sustainability Strategy NRW from a Scientific Perspective" of the Wuppertal Institute in November 2013, a "TEAM Sustainability" was convened, which will also be continued in a second research project of the Wuppertal Institute "Implementation Experience with State Sustainability Strategies—Case Study Sustainability Strategy NRW" (planned completion: December 2020).

The core tasks of the TEAM Sustainability consist on the one hand in the continuous reflection and constructive critical commentary of the project (interim) results from a social point of view and on the other hand in the pro-active input of information and findings from the respective work contexts of the TEAM members into the

[7]Respective the former Ministry for Climate Protection, Environment, Agriculture, Nature Conservation and Consumer Protection of the State of North Rhine-Westphalia until May 2016.

[8]The "Chief Dialog Sustainability" initiates a regular exchange between 15 mayors and district administrators, as well as the local central associations and the state of North Rhine-Westphalia. The "Municipal Sustainability Conference" provides information on the many political processes for promoting sustainable development and presents the already existing exemplary approaches of the local community. Two further project formats of the Network Sustainability NRW under the direction of LAG 21 NRW are the seminar series "Mandate Sustainability", in which volunteer mandate holders are informed about integrated municipal sustainability strategies and the "Model Project Municipal Sustainability Budgets" (LAG 21 NRW, n.d.).

research projects and their work packages. The support of the TEAM Sustainability ensures right from the start that the accompanying projects of the Wuppertal Institute for the Sustainability Strategy NRW are processed application-oriented. The TEAM Sustainability thus serves as an advisory board and discursive support of the projects of the Wuppertal Institute on the sustainability strategy NRW and thus indirectly the development and implementation of the sustainability strategy NRW from the stakeholder perspective by means of an open, internal factual discussion. The TEAM Sustainability also discusses and reflects on the state sustainability process and proactively provides its own impulses for the further development of the sustainability strategy NRW. Thus, the TEAM Sustainability is initially the project advisory board of the Wuppertal Institute, but indirectly the TEAM Sustainability is also available to the NRW state government as an advisor for the development and implementation of the sustainability strategy NRW—a Sustainability Advisory Council. The TEAM Sustainability brings together the central stakeholders from the economy, municipal associations, civil society and science in North Rhine-Westphalia. It is made up of sustainability-relevant social actors of the state of North Rhine-Westphalia and thus unites different social perspectives for the sustainability debate. Due to personnel restructuring and the expansion of the stakeholder base, the composition of the TEAM Sustainability team has changed at individual institutions since they were first set up.

The Head Office of the TEAM Sustainability for the preparation, follow-up and organisation of the meetings is located at the Wuppertal Institute. The supervision of the TEAM Sustainability is in the responsibility of the executive management of the Wuppertal Institute and for the coordination and organisation scientific employees are involved. The TEAM Sustainability has given itself in the beginning rules of procedure in which agreements were made on the occasion, the function and working methods of the TEAM Sustainability as well as the handling of publications. The TEAM Sustainability meets three to four times a year. If required, smaller workshops on specific topics are also held. In addition, the exchange takes place in written form by e-mail or via telephone or videoconference. In total, 12 meetings of the TEAM Sustainability took place between March 2014 and March 2018. The Membership in TEAM Sustainability is both institutional and personal so that personal and continuous participation is guaranteed. The Ministry for Environment, Agriculture, Nature Conservation and Consumer Protection of North Rhine-Westphalia participates as an observer in the meetings of the TEAM Sustainability and informs the TEAM Sustainability about the status of the (further) development of the sustainability strategy for North Rhine-Westphalia as far as the confidentiality agreements with the other ministries allow it. The meetings and the minutes of the meetings are not public. If required, guests (e.g. external experts; representatives of other ministries; other researchers involved in the Wuppertal Institute research project) can be invited on a case-by-case basis.

The TEAM Sustainability has produced a total of three written statements during the development process of the Sustainability Strategy NRW. The first statement, in the form of improvement notes from the TEAM Sustainability (Part A) on the process of strategy development for a state sustainability strategy in NRW, focused on

yes	All proposals have been implemented.
largely	Most of the proposals have been implemented.
partly	Some proposals were implemented.
no	No proposal has been implemented.

Fig. 3 Evaluation scheme of the impact analysis for the proposals of the TEAM Sustainability for the NRW sustainability strategy

structural and procedural improvement notes (Wuppertal Institute 2014). The second statement, in the form of improvement notes from the TEAM Sustainability (Part B), referred to the strategy paper of the North Rhine-Westphalia state government "On the way to a sustainability strategy for North Rhine-Westphalia" and formulated recommendations for improvement in content (Wuppertal Institute 2015a). The third written statement of the TEAM Sustainability commented on the draft of the state sustainability strategy for North Rhine-Westphalia (as of September 2015) (Wuppertal Institute 2015b). During the NRW Sustainability Conferences the individual members of the TEAM Sustainability and the institution of the TEAM Sustainability also gave direct suggestions for the further development of the sustainability strategy NRW. The TEAM Sustainability is currently working on a further statement with recommendations, this time focusing on the further development of the NRW sustainability indicator report.

An impact analysis was carried out to measure the impact and influence of the TEAM Sustainability on the development of the NRW sustainability strategy. The ex-post analysis shows to what extent the individual recommendations of the TEAM sustainability have been implemented. The results show an added value of the TEAM sustainability participation process. To examine the implementation of the proposals and recommendations in detail, the three publications of the TEAM Sustainability were divided into a total of 185 individual proposals in a first step. The classification followed the thematic classification within the comments. The evaluation of the individual proposals regarding their implementation in the Sustainability Strategy NRW (State Government NRW 2016a) and in the Sustainability Indicator Report NRW (State Government NRW 2016b) was based on a four-stage scale (Fig. 3).

To enable the evaluation to be verified, the corresponding passage in the Sustainability Strategy NRW or the Sustainability Indicator Report was indicated in a separate evaluation table for each proposal. A first comparison showed that a large proportion of the proposals adopted by the state government was not implemented literally but in terms of content. As a result, the wording check was only carried out for those bodies for which the proposals of the TEAM Sustainability also required an amendment or implementation of a specific wording (Fig. 4).

The results of the impact analysis show that most of the proposals (76.5%) were implemented completely or largely by the state government. Only one in four (23.5%) was considered only partially or not at all. This high proportion of implementation makes it clear that proposals and recommendations of the TEAM Sustainability have

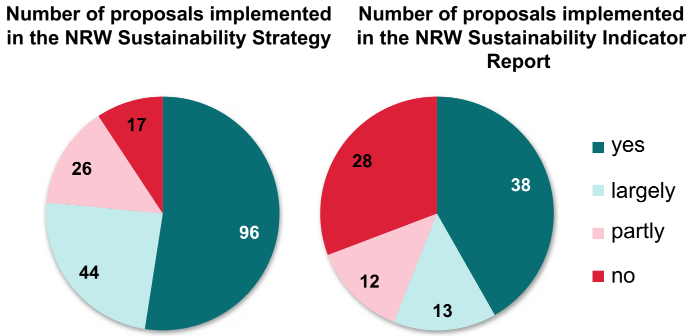

Fig. 4 Results of the impact analysis on the proposals of the TEAM sustainability for the NRW sustainability strategy

had an influence on the content of the NRW sustainability strategy. With reference to the NRW Sustainability Indicators Report, the results of the Impact Analysis show that 56% of the proposals and recommendations are completely or largely implemented. The lower degree of consideration of the recommendations of the TEAM Sustainability for the NRW sustainability indicator report can be explained by several factors: Firstly, a draft of the NRW Sustainability Indicators Report was not publicly accessible by the North Rhine-Westphalia State Office for Information and Technology so that no direct reference was possible. Secondly, the abstract, statistically designed format of the NRW Sustainability Indicator Report only provides general (improvement) information without access to a draft version. The results suggest that indicator-specific proposals of the TEAM Sustainability were increasingly considered in Part II "Goals and indicators; background indicators" in Chap. C "Implementation of the NRW Sustainability Strategy" of the Sustainability Strategy NRW (State Government 2016a, pp. 58–69) and not directly in the Sustainability Indicator Report NRW (State Government NRW 2016b).

5 Discussion and Conclusions

The results of the analyses of the sustainability architectures of the Federal Republic of Germany and the federal states of Baden-Wuerttemberg, Hesse, Saarland, Thuringia and NRW differ in central structural elements. The following overview lists the main features (Table 2).

With reference to the participation of non-governmental actors, the following question goes along: Is it advantageous to institutionalise an Advisory Council for Sustainable Development at the coordinating office of the state government for the sustainability strategy, as is the procedure of the federal states of Baden-Wuerttemberg, Hesse, Saarland and Thuringia? Against the background of the existing NRW sustainability architecture, however, any transferability to the state of North Rhine-Westphalia requires a differentiated consideration. The institutionalisation of the Sustainability Advisory Council and the founding of a Head Office by and within a federal state department, which is responsible for the sustainability strategy, is accompanied by advantages. In particular, direct involvement in the discussion and design of the implementation of the NRW sustainability strategy and a possible stronger link within the framework of vertical integration via the inter-ministerial working group "IMAG Sustainability Strategy". In contrast, however, the non-governmental advisory councils with the participation of non-governmental organisations like the TEAM Sustainability also show the strength of such a participation structure for the sustainable development in NRW.

With the TEAM Sustainability, which is organised by the Wuppertal Institute, the state of North Rhine-Westphalia has an architectural component that clearly distinguishes it from the sustainability architectures of other federal states. As the observations on the other sustainability architectures have shown, the Sustainability Advisory Boards of the federal states are institutionally located with the state government via a Head Office or with the department responsible for the sustainability strategy as coordinator. In contrast, the involvement of central actors in an advisory body via a non-governmental institution such as the TEAM Sustainability via the Wuppertal Institute has considerably less direct (formal) networking in the state institutions, but it also has advantages: On the one hand, impulses can be bundled and

Table 2 Specifics of the sustainability architectures examined

Baden-Wuerttemberg	• Youth advisory board, direct involvement of young people in committee structures
Saarland	• Legislative establishment of the appointment of an Advisory Council with the participation of non-governmental members
Hesse	• Task-Force "Targets and Indicators" • Sustainability Conference brings together actors from governmental and non-governmental institutions • Chair and participation in the Sustainability Conference of the highest management level (ministers of the country)
Federal Republic of Germany, Thuringia	• Parliamentary Advisory Board
Baden-Wuerttemberg, Hesse, Saarland, Thuringia	• Head Office of the Sustainability Advisory Council located at the State Government (state ministry)
North Rhine-Westphalia	• Sustainability Advisory Board organised through a non-governmental "Third Party" institution • Head Office of the Sustainability Advisory Council located at a scientific institution

passed on to the state government from a strongly independent perspective, which were previously discussed intensively and in an open internal exchange among the actors (i.e. without representatives of the state). There also appears to be greater flexibility regarding the members, since decisions on admission or resignation may not be justified (party) politically, but quickly and exclusively in terms of content and work organisation. Furthermore, the organisation of a Sustainability Advisory Council via a third institution is not tied to election cycles. Especially regarding the long-term impact cycles of sustainable development, this has an advantage, e.g. with regard to questions of intergenerational justice and the challenge of long-term thinking (Steurer 2010, p. 37). The positive effect that the "Third Party" approach can have on the organisation and coordination of Sustainability Advisory Councils is also confirmed by the results of the impact analysis. The results clearly show the added value of the TEAM Sustainability for the development of NRW's sustainability strategy.

The results suggest that scientific organisations and in particular interdisciplinary institutions and universities can and should take on a coordinating and organising role for Sustainability Advisory Councils within a governmental sustainability architecture. In this way, they can play an active role as co-developers of the governmental sustainability strategy and thus contribute to achieving the Sustainable Development Goals.

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Participatory Action Research (PAR) as a Research Approach for Sustainable Community Development: A Case Study in Pulau Mantanani, Sabah

Yasmin Rasyid

Abstract Current efforts and research on sustainable community development has garnered increasing interest among academicians, non-governmental organizations (NGOs) and government. Additionally with the global alignment on the Sustainable Development Goals (SDGs), there has been a strong emphasis on understanding the various approaches, concepts, and mechanisms of accomplishing or contributing to the successful implementation of the SDGs. Such studies often focus on the sustainability of interventions, whether initiated by the government or NGOs, to provide long term benefits to the beneficiaries or community. Nevertheless, the sustainability of interventions is widely debated in terms of identifying the various factors that are necessary for sustainable community development to materialize. As an interdisciplinary and transdisciplinary subject, researchers apply a variety of research methodologies in order to study, understand and analyse the sustainability of interventions for sustainable community development, a precursor to sustainable development. Using a case study approach, this paper documents the application of the Participatory Action Research (PAR) methodology in studying the sustainability of NGO interventions for sustainable community development. The values and limitations of the PAR approach as a research approach in studying the sustainability of NGO interventions for sustainable community development in Pulau Mantanani are presented in this manuscript and aims to encourage researchers on sustainable community development to integrate the PAR method in their research designs. The author argues that the application of the PAR methodology in research on sustainable community development is a suitable and robust methodology for researchers to capture in-depth, and inclusive and collaborative knowledge-generating perspectives with the community and generate action that aims to improve livelihood and reduce economic, environmental and social inequities of communities through involving the people who, in turn, take actions to improve their own livelihood. Additionally, this paper also aligns the benefits of the PAR method in facilitating research that contributes to the Sustainable Development Goals (SDGs).

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1 Introduction

One of the key overarching goals of the Sustainable Development Goals (SDGs) addresses reducing poverty (SDG 1—end poverty in all forms everywhere). Sustainable community development is necessary to facilitate the reduction of poverty and to meeting outcomes of the SDGs. Pertaining to the various academic, government and non-governmental organizations (NGOs) discourses on sustainable development, rural poverty and environmental degradation are very closely related and is often related to rural communities who depend on the direct and indirect use of their natural resources as their source of livelihood. Unfortunately, case studies (Adger 2000; Yu-hui 2005; Forsyth and Walker 2008; Wang et al. 2014) have demonstrated that the strong symbiotic relationship that bond humans and the environment in coexistence does not exist anymore.

Today, while interventions are being delivered by development actors to improve livelihoods of rural and marginalized communities, there remain various challenges which threaten the goals of the interventions in balancing both the integrity of natural resources and to enable current and future generations to benefit from these resources; in short, to attain sustainable community development. Depending on the development actors, various approaches have been explored to attain sustainable community development such as the provision of direct economic aid through government (Kenworthy 1999; Fan et al. 2000; Mosley et al. 2004) or NGO interventions (Johnson and Rogaly 1997; Bebbington 2004; Ahsan and Routray 2007); or by implementing government interventions to promote sustainable community development as an attempt to alleviate rural poverty (Brocklesby and Fisher 2003; Alison and Horemans 2006). However, the sustainability of these programs are in question as many of such interventions have been reported to be not successful in achieving the goals, as once external aid from a funder or donor has ceased, beneficiary participation in these interventions have been reported to reduce drastically or to non-existent levels (Reyes and Valencia 2003).

Researchers (Altman 1995; Kumar and Best 2006; Trickett et al. 2011) have indicated that some of the factors that influence the sustainability of interventions for sustainable community development may be either financial, material or human resources and also because the initial planning and development of the interventions did not practice inclusivity of the beneficiaries' interests and priorities. Other issues which are less explored in understanding the complexity of sustainable community development include power struggles, leadership, political interjections and management approaches of the development actors. Communities need to be included and involved in defining, and planning what they aim to achieve to improve their livelihoods, failing which the community's motivation will decline and thus prevent the community from being self-reliant (Shuman 2013). The concept of "leave no one behind" as emphasized by the SDGs illustrates the need for community involvement in all sustainable community development efforts.

In a case study of NGO interventions for sustainable community development in the island off the west coast of Sabah, Malaysia called Pulau Mantanani, the researcher initiated a collaborative community development research project with two key actors, the NGOs and the local community, as research participants in the design and delivering of NGO interventions aim at improving the livelihood of the community. The research focused on analysing the factors that influence the sustainability of the NGO interventions for sustainable community development using a Participatory Action Research (PAR) methodology. The PAR methodology is an approach to research in communities that emphasizes participation and action and seeks to understand a phenomenon by attempting to produce change (social, economic or environmental) in a collaborative manner through a series of reflection, collective inquiries, and experimentation that is justified in experience and social history.

Whitehead and McNiff (2006) hypothesized that the PAR methodology is a good approach to assisting in the process of raising economic development, increasing awareness of natural resource-dependency and capacity-building on a group level because the aim of PAR as an approach to research is to improve social or personal situations, rather than just understand and propose theories about the causes of the external situation. This manuscript will define the PAR method applied in this case study and proceed to describe the core features or principles of PAR which were applied as a methodology in this research and evaluate the application of the PAR method. This manuscript will also discuss the values and limitations of the application of the PAR methodology in studying sustainable community development towards attaining the Sustainable Development Goals.

2 Literature Review

2.1 Defining the Participatory Action Research (PAR) Methodology

The Participatory Action Research (PAR) methodology is an action-oriented research approach that emphasizes on an interactive, democratic inquiry and participatory process that involves researchers working in collaboration "*with*" and "*for*" the research subjects (also known as co-researchers, research participants or critical friends) towards a social, environmental or economic change (Reason and Bradbury 2001; MacIntyre 2007; Smith 2015; Bradbury 2015). PAR methodology is defined by Reason and Bradbury (2008) as "*a participatory, democratic process that seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people in their*

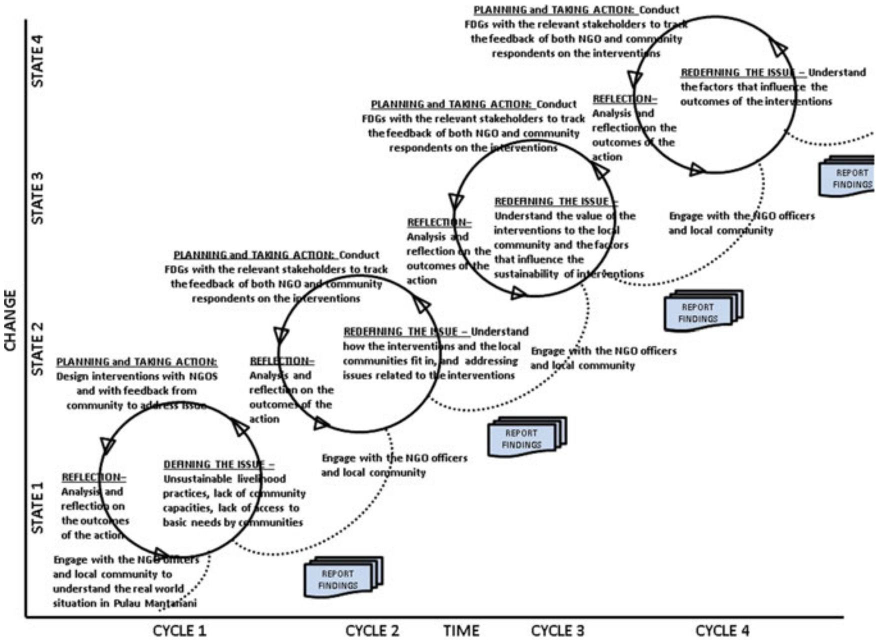

Fig. 1 The participatory action research approach, principles and cycles (*Source* Author's Construct)

communities". This perspective was strongly supported by the work of Freire (1972) who used PAR to encourage poor and deprived communities to examine and analyse the structural reasons for their oppression. Simplified, the PAR method is a learning process that focuses on learning by planning, doing, observing and reflecting,

The basis of the PAR methodology is based on the philosophy of critical theory, first developed by the Frankfurt School in Germany in the 1930s (Dillard 1991; Neuman 2000; Fals Borda 2006). The basic tenant of critical theory is that it views society as a fluid human construct. It focuses on improving the living conditions of people instead of accepting and coping with the existing situations (McGregor 2003). McGregor (2003) also noted that critical theory refers to the attainment of the desired improvement of human life. Additionally, PAR has been demonstrated by researchers to be a suitable approach to assisting in the process of raising economic development, increasing awareness of natural resource-dependency and, capacity-building and skills development on a community level. Unlike the traditional approach to research, the PAR methodology focuses on research in which the purpose is to enable action be it economic, environmental or social. Action is achieved through a reflective cycle, whereby participants collect and analyse data, then determine what action should follow. The resultant action is then further researched and an iterative reflective cycle perpetuates data collection, reflection, and action as in a corkscrew action (Fig. 1).

In the last six decades, various theories by researchers have contributed to the justification, evolution and practice of PAR in various disciplines. Argyris et al. (1985) argued that the PAR approach is different from traditional research in which environmental variables are controlled and researchers to find out cause and effect in an isolated environment, while PAR openly inquires about conflict and possibly works on transforming the variables in a cyclical learning cycle. The following sections will illustrate the core principles of the PAR methodology.

2.2 *Principles of the Participatory Action Research (PAR) Methodology*

In the last two decades, studying social, organisational, environmental, and economical changes within a specific community has raised the profile of a particular research methodology known as Participatory Action Research (PAR) (Reason and Bradbury 2001; Pain and Francis 2003). The PAR approach possesses three strong key principles. The first key principle is that the PAR approach is "*action-oriented*" and is underpinned by the belief that "*the study of society is not worth the trouble if it does not help its members to grasp the meaning of their lives and to move to action for progress, peace and prosperity for all*" (Fals Borda 2006). Secondly, PAR is participatory and thus involves researchers working "*with*" and "*for*" the research subjects, also known as co-researchers. Thirdly, the PAR method focuses on reflective learning and generation of rich knowledge and information through the application of through a diverse range of quantitative and qualitative research techniques and tools. Reflective learning and new knowledge and information have the propensity to contribute to improvements for further development efforts.

In a PAR approach, the researcher initiates the research by engaging with a real situation faced by a community. Upon engaging with the real state of affairs, the researcher then initiates the research with an inquiry stage (Fig. 1) where the PAR researcher and the research participants identify a shared real-world problem, defined the shared problem clearly and identified and obtain consensus on the action needed for the research participants to collectively address that problem. Once this is achieved, the next stage is implementation of the action or intervention phase in which the researcher and the research participants implement the agreed action(s) or intervention(s). In the action implementation phase, the role of the researcher is to closely monitor, and observe the research participants throughout the entire process of action or intervention implementation. Within this phase, the researcher's observations are collated into reflections which are then shared with the research participants to validate new and emergent knowledge or information generated from the researcher's observations and reflections. The new knowledge generated is then used as units of inquiry when the researcher repeats the PAR methodology or cycle again, thus, tracking the process of social change towards attaining the outcomes of the desired interventions.

The PAR methodology is a repeated rigorous cycle of inquiry, action and reflection which provides a robust frame of reference for the researcher to observe, document, and critically analyse the various factors that influence the research participants in attaining a change in their livelihood. The generation of knowledge and information obtained from the research process can be used as baseline data-set to help assess the social, economic and environmental changes to the livelihood of the local community as a consequence of the PAR methodology. In this aspect, the PAR approach is able to facilitate the generation of information to expose a potential hidden social oppression through self-realization and enlightenment in a society (Morgaine 1994). Literature (Chambers 1997; Cooke and Kothari 2001; Cornwall and Pratt 2003; Bleckley 2008) has demonstrated that PAR is commonly used by a whole range of community groups and NGOs (where people already know each other and/or work together), and also by groups that come together for the purposes of research and action on a particular issue. Additionally the PAR approach has also been applied to a wide range of research disciplines from public health (Wallerstein 1999; Tsey et al. 2004; Trickett et al. 2011), ecological studies (Wang et al. 2014) and economic studies (Morgaine 1994; Kenworthy 1999; Reyes and Valencia 2003). These authors also reinforce the notion that in a PAR approach, the researchers act as external figures that "*provide people with the support and resources to do things in ways that fit their own cultural context and their own lifestyles*".

Bordieu (1983) noted that the primary aim of utilizing the PAR method is not to change practice in the course of research, rather, the aim is to produce knowledge in collaboration between researchers and practitioners. The following sections will describe the distinctive fundamental principles of the PAR method to demonstrate to both the qualitative and quantitative research community that the PAR method and framework is a method that opens up new broader transdisciplinary perspectives for the field of sustainable community development.

2.2.1 Action-Oriented Research Approach

In traditional research, the researcher is an external observer who proposes theories, while in participatory action research (PAR) the "objects of research", also known as the community or practitioners, are integral parts of the research and play its role as a research collaborator as they generate their own living theory of practice. What is different in the PAR approach compared to the traditional research approach is "*the attitudes of researchers, which in turn determine how, by, and for whom research is conceptualized and conducted and the corresponding location of power at every stage of the research process*" (Cornwall and Jewkes 1995). This means that the PAR researcher is constantly addressing space and power discourses through the timeframe of the PAR period. PAR advocates that those being researched should be involved in the process actively. The degree to which this is possible in sustainable community development research will differ as will the willingness of people to be involved in research.

PAR also provides the opportunity for inclusive community involvement in the development and ownership of sustainable community development interventions, by allowing for clarifications and reflections that might improve the researcher's and community's understanding of situations and problems to shape their strategies rather than prematurely introducing external ideas This principle is strengthened by the opinion of Cooke and Kothari (2001) who argue that "*action-oriented participation helps to take the learning process of the intervention beyond reflection and towards capacity-building, which builds the knowledge and skills for participants to act in their community as leaders or agents for creating change*".

2.2.2 Researching "with" Rather Than "on" People

Whitehead and McNiff (2006) hypothesized that the aim of utilizing the PAR method in community development research is to improve social or personal situations, rather than just understand and proposed theories about the causes of external situation. The authors highlighted the fundamental differences between the PAR and traditional research methods based on what is studied, how it is studied and represented, as well as why it is studied. Compared to a traditional researcher where he or she is the external observer who proposes theories, the PAR researcher focuses on utilizing a combination of tools and techniques where the "*object of research*" is the community. This requires the PAR researcher to pay full and careful attention to power relationships among the research participants, and negotiating for access and advocacy to a democratic space and approach between the researcher and the community where both researcher and community is able to clarify and reflect on their actions. In a PAR research, people are considered as the active agents for bringing about social transformation; however, they are often trapped in a web of societal myths, obligations and relationships (Neuman 2000). In such a scenario, the PAR researcher tries to unravel the existing problems of oppression, exclusion, biasness, power abuse etc. within a society, and target ways to bring social transformation through self-realization, emancipation and empowerment under the existing circumstances (Dillard 1991). This democratic approach of the PAR method generates rich knowledge and information to help the researcher and the research participants strategize on designing and implementing interventions rather than relying on external ideas from the researcher. Literature has also indicated that it is essential and normal to for a PAR researcher to practice blurring the line between the researcher and the researched until the researched become the researchers (Freire 1982; George et al. 1996; Wallerstein 1999; Smith 2015).

2.2.3 Collective and Cooperative Reflection with Growth of Knowledge

The PAR approach challenges the traditional research approach by moving beyond reflective knowledge created by outside experts sampling variables, to an active moment-to-moment theorizing, data collecting, cycles of reflection and inquiry occurring in the midst of emergent structure. "*Knowledge is always gained through action and for action. From this starting point, to question the validity of social knowledge is to question, not how to develop a reflective science about action, but how to develop genuinely well-informed action—how to conduct an action science*" (Torbert 2001).

Stringer (1996), Brydon-Miller (2004), and Greenwood and Levin (2006) noted that the PAR method focuses on the cooperative relationship between participants and researcher and there is a permanent respect for knowledge of the participants and for their ability to understand and address the issues. Literature has (Chambers 1997; Cooke and Kothari 2001; Cornwall and Pratt 2003; Bleckley 2008) demonstrated that PAR is commonly used by a whole range of community groups and NGOs (where people already know each other and/or work together), and also by groups that come together for the purposes of research and action on a particular issue.

2.3 Application of the PAR Methodology in Sustainable Community Development

As a component of sustainability development, sustainable community development studies is developed out of the convergence of two perspectives – that of science and action. This means that sustainable community development studies cannot be canonized in the form of a single, cohesive methodological approach, such as for example, the narrative interview of a qualitative content analysis, or the results from the respondents of a quantitative survey analysis. In essence, sustainable community development studies require the researcher to conduct their research process with people whose life-world and actions are under study.

Literature argues that sustainable community development studies is a transdisciplinary field of study which requires a participatory method where researchers and co-researchers collaborate in order to gain a deeper insight and understanding into the contextual structured-ness of meaning and the dynamism inherent in sustainable community development. Bergold and Thomas (2012), for instance, argue that a methodological design that is participatory represents and provides an attractive and fruitful knowledge-generating opportunity to the researcher when it comes to researching sustainable community development especially in the areas of development interventions. Reason and Bradbury (2008) made a case that there is a strong movement towards the adoption of "participative inquiry and practice" within the debate on sustainable community development. They noted that numerous discussion and research strands, in which the participation of research partners is conceptualized in different ways, can converge in the sustainable community development research paradigm.

It is argued by researchers that the adoption of the PAR methodology in research on sustainable community development make sense because the goal is to change social reality on the basis of insights into everyday practices that are obtained by means of participatory research—that is, collaborative research on the part of scientists, practitioners, service users, etc. (Bergold 2007; Reason and Bradbury 2008). One of the key advantages of using the PAR method in studying sustainable community development highlighted by Greenwood and Levin (2006), Stringer (1996), Brydon-Miller (2008) and Maguire (2000), is that the principle of mutual or cooperative inquiry and relation between the researcher and the participants, there is a permanent respect for knowledge of the members and for their ability to understand and address the issues. The authors further reinforced the notion that a PAR researcher acts as an external figure that "*provide people with the support and resources to do things in ways that fit their own cultural context and their own lifestyles*".

Examples of the application of the PAR method in sustainable community development studies have been demonstrated in case studies which were observed and researched by Selenar (1997) and Tsey et al. (2004). Selenar (1997) noted that the PAR methodology was applied as an approach in research in community development; action research in organizations; action research in schools; and farmer participatory research in which the author observed and study the main components and principles of PAR being applied, the role of the researcher in PAR and also the observed outcomes of the PAR method. The author concluded that the application of the PAR method provided positive implications especially for the researcher and society as a whole as the PAR methodology required inclusive and a high level of participation from all community, emphasizes on a democratic involvement, and as a method, provides a high potential for social change within the community.

In a sustainable community development research by Tsey et al. (2004), the researchers utilized the PAR method to help understand if the establishment of rural Aboriginal men's health groups were benefitting the Aboriginal men's well-being. The PAR application in the inquiry revealed that the men's health groups improved social and emotional well-being of the male participants, encouraged modest lifestyle modifications and increased the willingness of the men to change their current notion of "gendered" roles within the home such as sharing housework with their spouses. It was concluded by the researchers that the men's public health groups provided a sense of empowerment to the male participants and catalysed them to take action to improve their living condition and situation at home. The study also indicated that the PAR approach in the study encouraged the male beneficiaries to self-report and as such increased the generation of knowledge for the researchers on the impact of the men's health groups. These studies and authors have demonstrated that performing PAR is the same as performing an experiment, thus it is an empirical process (Whyte 1991; McTaggart 1991; Greenword et al. 1993; Reason and Bradbury 2001; Kemmis 2006; Smith 2015).

3 The Pursuit of a Sustainable Livelihood in Pulau Mantanani, Sabah

Pulau Mantanani is one of the few pristine island located on the western coast of the state of Sabah (Fig. 2). The island is close to two kilometres long and is surrounding by the South China Sea on the east and north. A shipwreck diving paradise, Pulau Mantanani is a preferred tourism destination for both local and international tourists. The local community is of the Bajau Ubian ethnic group and majority of them work as artisanal fishermen to meet their daily economic needs. What was once an island abundant with fishing activities is now threatened by ill-planned tourism activities, and illegal fishing practices like fish bombing, which has resulted in a serious depletion of coral reef population, marine life and resources that are found around the island.

In the case of Pulau Mantanani, the local Bajau Ubian community is also facing other challenges related to their livelihoods. Poverty is one the main issues faced by the local population on the island of about 800 Bajau Ubian community members (Hussin et al. 2015). The lack of diverse economic opportunities and also the lack of proper skills and knowledge on other economic activities have forced the local community to be solely dependent on their fishing skills and methods (Hussin and Weirowski 2013).

Fig. 2 A map of the location of Pulau Mantanani in Sabah, Malaysia (*Source* Google Maps)

With decreasing fish catch, and the encroachment of bigger fishing vessels within the boundaries of the island, the local fishermen community is unable to generate sufficient income for their households. This has led the fishermen community to resort to two alternative ways of ensuring they can sustain their fish catch. One of the alternative ways is the illegal use of fish bombs to fulfil their fishing needs. The fish bomb when detonated immobilizes the reef fish temporarily and makes it easy for the fishermen to then scoop the immobilized reef fish which is later sold in the markets as processed salted fish. The indiscriminate and illegal usage of fish bombs is detrimental to the surrounding maritime environment as the detonated bombs release hazardous toxic chemicals in the ocean (Woo et al. 2013; Reef Check Malaysia 2015; Hussin et al. 2015). In addition, fish catch from the use of fish bombs may contain toxic chemical residues like cyanide and arsenic, and when processed as salted fish and sold to the market in the mainland, can pose health risks and threats to consumers.

A second alternative for the fisherman community is to conduct their fishing activities further from the island. However this has raised severe concerns especially on occupational, environmental health and safety issues. Pulau Mantanani is surrounded by close to three oil and gas platforms located between 25 and 30 kilometres away. Over the last decades, the lack of fish catch in their usual fishing grounds has forced the fishermen to encroach within the oil platform boundaries. This is due to the fact that there is abundance and high diversity of fish population around and under the oil platforms. As such, this discovery has attracted desperate fishermen from Pulau Mantanani and also the mainland. The close proximity of the fishermen and their boats to these oil platforms poses a threat to the platforms as a typical fisherman would fish right underneath the platforms as fish population beneath the platforms are in abundance. The risks to the environment and the platform increases when the fisherman starts a small fire in his boat to cook lunch while he rests under the platform with his boat tied to the platform. The risk intensifies when the fishermen detonates the fish bombs near the oil and gas platforms. This pose safety, environmental and occupational threats to the oil platforms which are forced to shut down their oil extraction process as a precautionary measure. This is not favourable to the oil and gas company as any cessation of oil extraction activities results in delays in production which means a reduction in sales and profits. Therefore, it is of great interest for the oil and gas company to minimize the encroachment of fishermen into the boundaries of their oil and gas platforms. The challenge the fishermen community face is that they are unable to sustain their current livelihood status with the existing economic activities on the island which is predominantly artisanal fishing. Knowledge, skills and capacities in other income-generating activities are lacking due to lack of opportunities, education and community capacity in other income-generation activities. This then further forces the fishermen to risk their lives and that of the oil and gas platforms by relying on detrimental fishing methods to meet their daily needs.

Additionally, the local community also lack access to basic facilities like education, health care facilities, and infrastructure. The local primary school on the island, Sekolah Rendah Kebangsaan Pulau Mantanani, has one of the lowest passing rates in the country and as such, majority of the local community members have only completed their education till they were 12 years old. Without any electricity, the school faces many challenges in maintaining its operations. Currently, the community relies on diesel-powered generators for electricity. Renewable sources of energy are absent and as such, majority of the households (including the school) are without electricity. Due to its distance from the mainland, there is no treated piped water supplied to the island as such the community relies on ground water resources. However, the ground water resources have been reported by an NGO, Arkitrek (GEF-SGP UNDP 2013) to be severely contaminated with *E. coli* as there is an absence of sewage treatment facilities on the island. The current method of sewage disposal on a household level has contaminated groundwater resources. This has resulted in the community resorting to purchasing bottled water from the mainland, which adds on to their daily expenditure on the island. The improper management of sewage from the land has also been reported to be one of the key threats on the surrounding coral reef population (Reef Check Malaysia 2015) which results in poorer maritime water quality.

Transportation to and from the island is intermittent and due to the distance between Pulau Mantanani and the mainland in Kota Belud, there has been many reported incidences of capsize due to erratic weather conditions. During the research period, the community did not have access to telecommunication facilities and only selected community members could afford satellite phones. Since the early 2000s, several NGO interventions have been initiated on the island with the local community however many of the interventions remain underutilized by the local community. Despite the continuous efforts of NGO interventions in ensuring that the sustainable livelihood of the local community is addressed, many of the interventions have failed to ensure that the development of alternative and sustainable livelihoods is attained.

Tourism development in Pulau Mantanani was first observed in the existence of tour operators on the island few years back and since, has rapidly progressed (Jaafar et al. 2016). Jaafar et al. (2016) noted that the intense tourism development has affected the local communities' such as commodification, adaptation to tourist's demands and it alters the local identity because of the increasing number of accommodations. The current government initiated high-impact tourism development program on the island has also affected the lives of the local Bajau Ubian community both in a positive and negative way. While the locals welcome some potential extra income in their lives, the frequency of the income is irregular. What is noted by the researchers is that the local Bajau Ubian community is concerned about the threat of foreign culture and values on their local traditional culture and values. Other researchers like Noor et al. (2017) noted that the local Bajau Ubian community is motivated to explore entrepreneurship due to the potential economic benefits that can be gained from being an entrepreneur. Some of the potential areas for entrepreneurship development have been identified by Noor et al. (2017) for the local community include homestay development, small business (guiding, snorkelling) based on natural resources, local handicrafts and cultural programs, and community volunteerism for corporates, however the authors noted that the local community require support in order to facilitate the adoption of entrepreneurship on the island. Some of these supports include infrastructural facilities and also skills and capacity development programs.

Currently most of the tourists are day tourists as the island lacks the proper facilities to accommodate overnight tourists such as electricity, water, and other facilities. The increased in tourist arrivals to the island, often for day trips, have also resulted in visible physical impacts on the island. Indiscriminate disposal of solid and organic waste, lack of sewerage facilities, and a severe deterioration of the maritime environment in terms of coral reef biodiversity. With the development of resorts and hotels, the aim of the tourism industry is to extend the length of stay for tourists on the island which can contribute to an increment in tourism income. As stipulated above, the island lacks water resources and sewage management facilities, and with the intense growth of tourism on Pulau Mantanani, the locals are fearful that the island's resources would be depleted. In addition, the local community is also pressured to vacate the island and relocate to the mainland to make way for the state's tourism development plans on the island. There have been some efforts by local politicians and members of Parliament who are tasked to convinced the locals to move to low cost housing flats built by the state government to facilitate the easier transition and movement of the island community to the mainland. However, this has resulted in a strong opposition by some groups within the local community.

Pulau Mantanani, with its scenic and picturesque landscapes, is at a crossroads of addressing the needs of the local community, the intricacies in balancing high-impact tourism development, a sustainable livelihood for the community, and proper environmental management of the island. The lack of access to clean water, the deteriorating marine environment, lack of skills and capacities of the local community, and the lack of alternative economic activity has resulted in the initiation of the Alternative Livelihood program where four environmental NGOs combined their resources, efforts and strengths to address the development of sustainable communities and livelihoods on Pulau Mantanani. Funded by a single donor for two years (2013–2015), the Alternative Livelihood Program is a multi-NGO collaboration and partnership to engage the local Bajau Ubian community and implement interventions aimed at developing alternative income-generating activities such as homestay tourism development and a community-based environmental management plan that would address minimization of the impacts of the community's activities on the maritime environment. With the implementation of the Alternative Livelihood program, the objectives of the interventions designed and delivered are to enhance community capacities in other income-generating activities, reduce the impact of land-use and maritime activities (sewage and waste) on the environment, and encourage community participation, action and empowerment in the NGO interventions to ensure the continuity of the benefits of the NGO interventions planned and implemented in the Program.

The researcher negotiated for and gained access to the real-time phenomenon as a volunteer of the NGO and also as a sustainability researcher. The researcher negotiated for the application of the PAR methodology as a research approach in the Alternative Livelihood Program which was agreed up by the local community and the NGOs. The areas of interest for the researcher is to observe and document the application of the PAR method in the NGO and local community's research and collaboration to design, and implement NGO interventions to improve the livelihood conditions of the Bajau Ubian community.

4 Research Methodology

The PAR methodology utilized in this research used a range of qualitative and quantitative methods, depending on the stages of the PAR (define issue and plan, taking action, reflection). For the semi-structured interview, 178 local community respondents were selected based on the criterion that they have been involved as an active participant, facilitator or beneficiary of any of the NGO interventions delivered to the community within the timeframe (2013–2015) of the Program. Similarly, the 14 NGO respondents selected represented all the NGO respondents involved in the planning, development and implementation of the interventions within the timeframe under the Program.

The PAR cycle was repeated in four cycles between 2013 and 2015, and the knowledge and data generated from the PAR processes provided insights to help the researcher observe and understand how the research participants (NGOs and the local community) work towards a social change like attaining sustainable community development (through homestay development) through the NGO interventions. The repeated cycles of PAR in this research helped produce the concept of "voice" which

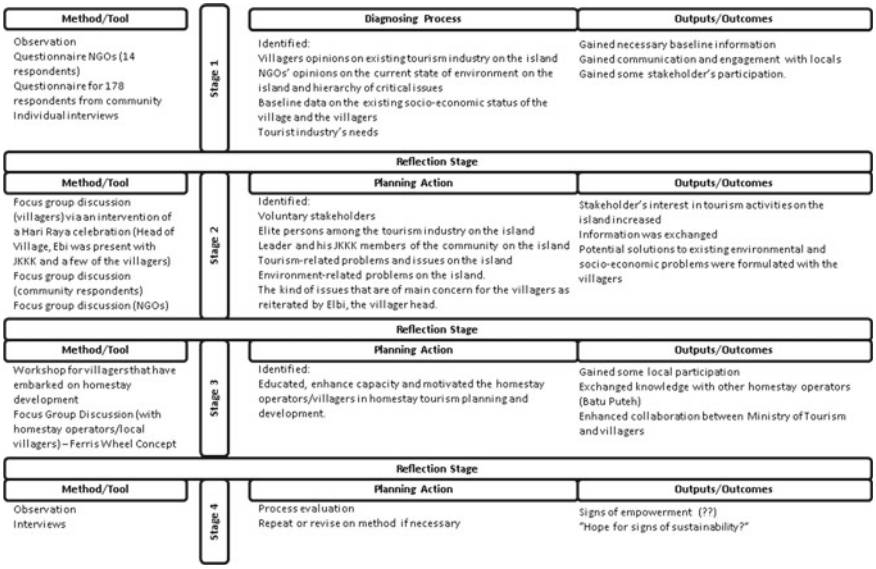

Fig. 3 The quantitative and qualitative research methods and tools utilized in the PAR approach in the study

Table 1 A summary of the application of sampling tools and techniques to the participants of the research

Tools and techniques	Research participants				
	Local community (homestay operators)	Tour industry sectors	NGOs/civil society organisa-tions	Government agencies	Funders/ donors
Semi-structured questionnaire	X		X		
Keeping a journal of thoughts, observations and reflections, collection of opinions from co-researchers	X	X	X	X	X
Preliminary meetings(formal and informal) with local community, NGOs, and relevant stakeholders	X	X	X		X
Interview (with Key Co-researchers/Critical Friends), diagnosis and reflection with co-researchers	X	X	X		
Participant observation in work-shop/Community events/Forums/ Engagement activities	X				
Focus group discussions	X April/May 2013 June 2013 Aug 2013 April 2014 June 2014 April 2015		X April/May 2013 June 2013 Aug 2013 Oct 2013 April 2014 June 2014 April 2015	X April 2014	X Aug 2013 April 2014

included research participants' feedback, insights and participation in the NGO interventions. Figure 3 details the quantitative and qualitative methods and tools utilized in the PAR approach used in this study. Table 1 details a summary of the quantitative and qualitative research tools used with respect to the various research participants.

5 Key Findings and Discussion

Within the Alternative Livelihood Program initiated by the NGOs, and through collaborative and participatory inquiry with the local Bajau Ubian community, it was established that the local community are in search of alternative economic opportunities for their village. The discussions and engagements between the NGOs and the local community resulted in the agreed initiation of entrepreneurial activities managed and delivered by the NGOs to enhance the local community's skills and knowledge in homestay entrepreneurship. Throughout the timeframe of the Alternative Livelihood program, the local community and the NGOs worked collaboratively to develop an action plan, implement the plan and reflect on what they have learnt from the development and delivery of the plan. Various issues, challenges and concerns were raised throughout the intervention implementation duration, in which the resolution was to conduct open discussion, focus group discussions, and interviews to reflect on the issues with the aim of generating new knowledge to re-define the plan and action necessary in order to ensure the interventions can continue to deliver benefits to the local community. As a result, a local village cooperative was formed by the local community to assist in the provision of a structured approach to homestay entrepreneurship development. The Bajau Ubian community realized that in order for the homestay tourism to derive continuous benefits, they would need to address better environmental management of the village and the seas and a strong support to develop their skills and capacity in homestay tourism. Although the Program ended after three years due to the donor's withdrawal the impact of the NGO interventions still continue to be seen on the island as the local community are progressing in expanding their homestay tourism program through various official government channels such as registering for government training and certification programs on homestay entrepreneurship. This indicated that despite the exit of the NGOs, some of the benefits of the intervention continue to provide values to the local community. For instance, the cooperatives engaged with the local government to provide internet connection to the islanders. Internet communication was identified by the community and NGOs as a necessary infrastructure to allow the homestay operators to market and promote their homestay services online. The local homestay entrepreneurs are also active in engaging with other NGOs and funders to conduct volun-tourism activities on the island in which the locals derive economic benefit from providing volunteers with accommodation, meals and transportation. As such through the NGO interventions delivered under the Alternative Livelihood Program, the outcome was a gradual adoption of alternative income generating skills and opportunities to reduce the community's reliance on fisheries income.

The main finding of this PAR research demonstrated that the creation of the community cooperative for homestay entrepreneurism is not the sole solution to alleviating poverty. Rather, the participatory collaboration method helps empower the local community to take action in areas such as skills development capacity-building, to complement their homestay entrepreneurship effort. This led the research participants (NGOs and local community members) to increase control over their lives by nurturing community strengths, acknowledgement and recognition of the weaknesses within the community and the overall government or political system, and enhance the problem-solving abilities of the research participants.

The findings from this case study revealed that in order to encourage and empower the local Bajau Ubian community to be interested in public participation in community development efforts, individual- and community-based knowledge management needs to be attained. One of the hardest elements to address in sustainable community development is addressing power struggles or discourses, and encouraging local community to gain social literacy on the real-time phenomenon in which they (the local community) may feel trapped in. The PAR methodology demonstrated that its principles and approach is able to bridge these challenges. This observation supports Chataway's (1997) argument that often in rural and indigenous communities, the local community members protect themselves from making public contributions to research by participating privately, and hence a continuing process of consensus is needed in all stages. Recognizing Chataway's argument, the PAR method as a research approach and through its principle of "researching with" the community, it can be deduced that the PAR method is valuable to research on sustainable community development as the approach emphasizes on the concept of "voice" of the community

In the case of the Bajau Ubian community in Pulau Mantanani, their daily practices and decision-making process are strongly influenced by the socio-cultural context. Thus, in order to gain the trust and confidence of the local community in the research, the researcher brought her own personal data with the expectations that the researcher would be able to open up to the local community and gain their trust. The researcher explored the island as a visitor with her family and connected very well with the local women on the island, as well as the children. She was also very mindful on being more conservative in her attire and social interactions in respect of the local conservative culture and to ensure that she is not interfering with the local customs. The researcher also lived in with many of the local community members in their own homestay, participated and contributed to the local island events and activities, and leverage on the lived experience to gain entrance or acceptance to the local community's cultural and social context.

This demonstrates that the PAR methodology is indeed a part of sustainable community development and that as a research methodology, is best suited as an approach as a decision-making process in advocating for a social change in a community. The PAR method assisted both the researcher and the local community feel a greater sense of community and clarity about their socio-cultural needs and requirements with the inclusive participation of all the relevant actors on the island.

5.1 Values of Adopting the PAR Approach as a Research Methodology for Sustainable Community Development

The PAR methodology adopted in this case study as a research approach to studying sustainable community development provided evidence for a set of values in which the PAR method can be further explored and applied in other potential areas of research. The values are elaborated in the next section.

5.1.1 Inclusive Participation

One of the essential aspects of research on sustainable community development is the inclusive participation of all the relevant stakeholders. As a researcher, the committed participation of the research participants reflected on the need of the researcher to observe and overcome her professional dominance and demonstrate and show commitment to democratic principles. This demonstrates that in any community development efforts, sustainability of such development efforts should no longer be a top-down process but should emphasize on a bottom-up inclusive participation of those whose development was being attempted (Oakley 1991). By ensuring that the process of participation is inclusive, democratic and aimed at addressing the collective improvement of a social situation within a community, the PAR methodology as a research approach is valuable as it generates rich knowledge that combines both professional and community perspectives. In the case of Pulau Mantanani, all the NGO officers that were in charge of planning and delivering their interventions to the local community participated in the research and provided a robust range of data and knowledge important for understanding the dynamics of empowerment, sustainability and community development.

5.1.2 Addressing Power Discourse and Community Empowerment

The fundamental concept to the PAR methodology is to achieve empowerment of those involved. In the case of Pulau Mantanani, the local Bajau Ubian community is headed by a village head which has been elected by the locals. The village head had stayed in the same position for more than a decade and has resulted in some discomfort in some of the community members as many felt that the village head was only allowing his family members to benefit from hand-outs from the tourists and government. This imbalance of power within the community has resulted in dissatisfaction among some of the community members in terms of how the community can develop sustainably and reduce the element of poverty in the island. The PAR method challenges the local island system of leadership and knowledge. When the community research participants were given the opportunity to control the research agenda, and to play an active role in the research, they established themselves as powerful agents of change. Over the duration of the Alternative Livelihood Program, awareness on the collective needs of the community, and the various approaches that can be utilized to address these needs rose and resulted in the individual community members raising their "voice" to the village head to provide suggestions or views on how the entire community can collectively address the issue of environmental deterioration and poverty on the island. In 2016, a new village head was finally elected replacing the previous village head's governance system, and majority of the local community initiated organizational change through the establishment of a homestay cooperative to improve their capacity to work in partnership with more NGOs, and other communities.

It can be deduced that the PAR methodology approach in research on sustainable community development provides community members with more power over the practices of government and private institutions and initiate organizational change to improve their own capacity and eradicate poverty in their community.

5.1.3 Live-in Experience

The traditional research approach is a mathematisation of the scientific world in which the real property of things needs to be measured, counted and quantified. The scientific world is systematic and organized in data and information. However, in the real world, there are many uncertainties and ambiguities. Compared to the traditional research approach, the PAR approach draws on unravelling phenomena and experiences that cannot be described in isolation from cause-and-effect situations. Real-world and internal experiences and challenges cannot be separated or isolated from the objective needs of traditional research. Understanding real-world experiences enable communities including researchers to engage in real-world issues and unite in subject and object (Thomas 1998) to evoke a particular social change in the community. In the case of Pulau Mantanani, the researcher immersed in a lived experienced by staying with the local community and also with the NGOs delivering interventions on the island. The lived-in experienced provided the researcher with rich knowledge and information that contributed to the generation of activities, workshops, focus group discussions, and even community events that focused on socio-economic improvement for the people on the island.

5.1.4 Critical Reflection

The social realities of Pulau Mantanani point to a livelihood that is unsustainably infused with poverty with severe lack of skills and capacity of the Bajau Ubian community. Critical reflection of temporal observations made in the local phenomenon helped address the social reality faced by the local Bajau Ubian community on the island, setting the basis for understanding on defining and agreeing to taking actions for change by radically calling into questions the current socio-cultural environment they are in. Additionally critical reflection is also important for the researcher as it provides information for the researcher to plan and organize his or her next course of action.

The PAR framework argues that people are the active agents for bringing about social transformation; however, they (people) are often trapped in a web of societal myths, obligations and relationships (Neuman 2000). In such a scenario, the PAR researcher works critically to unravel the existing problems of oppression, exclusion, biasness, power abuse etc. within a society, and target ways to bring social transformation through self-realization, emancipation and empowerment under the existing circumstances (Dillard 1991). Thus, a PAR approach helps seek to expose a hidden social oppression through self-realization and enlightenment in a society (Morgaine 1994).

5.2 The Limitations of the Participatory Action Research (PAR) Method in Studying Sustainable Community Development

Despite the immense values of the PAR method highlighted above, the case study also documented some limitations to the application of this approach in studying sustainable community development. The limitations identified in this case study are elaborated in the next section.

5.2.1 Time and Resource Intensive

A high degree of investment in terms of time and relationship is one of the requirements of the PAR method which can be exhaustive for a researcher. Apart from gaining trust and forming close working relationships with the local Bajau Ubian community, the researcher is required to invest time and resources to plan, initiate and participate in the community's functions and events, and at times, blur the role of a researcher and be a confidante to some of the local community members. Being a married female researcher resulted in the development of a strong bond or friendship between the researcher and the local female community members where issues on gender equality, contraception, education for children, and alternative income generation by females were raised as concerns of the women in the Bajau Ubian community. As such if the researcher is not willing to open up, or interested to have others open up to them in community development research, the PAR method is a limitation to the researcher.

5.2.2 Focuses on the Need of the Community, and not that of the Research

A traditional researcher expects empirical evidence of a cause-and-effect and typically hypothesizes in advance prior to studying a phenomenon. In this case, the researcher plays the dominant role and a successful traditional research outcome would be for instance define a successful research in terms of how the research outcomes allows for the formation of an original idea or outcome for the purpose of advancing knowledge and research in a peer-reviewed body of academia. Compared to a PAR researcher, the emphasis is on the needs of the community and a successful PAR research generates an outcome which in the case of Pulau Mantanani, is about a community-based participatory approach to reduction of poverty in Pulau Mantanani through NGO interventions aim at building the capacity of the local community on homestay tourism development, and a community-based environmental management plan endorsed by the local community.

6 Summary of the Findings and Discussion

In this case study, the Alternative Livelihood Program initiated by the NGOs for the benefit of the Bajau Ubian community in Pulau Mantanani has demonstrated real-life issues and challenges faced by both the local community and NGOs in attaining a sustainable livelihood on the island. Underpinning these issues, this case study focused on the application of the PAR methodology as a research approach in understanding and documenting the various factors that influence the sustainability of the NGO interventions for the sustained benefit of the local community.

The PAR methodology demonstrated some values and limitations to research on sustainable community development as indicated in the previous section. Nonetheless the contribution of the PAR methodology is immense and is argued to the best fitted methodology in all sustainable community development efforts especially for the benefit of development actors like government agencies and NGOs. Government agencies in their effort to deliver interventions to improve the development issues faced by communities may have the funds, political support, and governance structure to mobilize their resources to deliver interventions; however government agencies, unlike NGOs, lack the proximity and element of trust with communities. As such, NGOs are still seen as better vehicles of delivering interventions for improvement of livelihood of communities.

The PAR approach would also be able to provide both the NGOs and the government with more knowledge and information, capture the real "voice" of the beneficiary communities, encourage community empowerment with the inclusive and democratic participation of community members, and an opportunity for the intervention deliverer such as NGOs or government agencies, to reflect on their actions and their role in the bigger picture of sustainable community development. For the PAR researcher, his or her role is to work in close partnership with civil society organizations and development policy makers and practitioners including government and donors. The PAR methodology provides development actors such as government and NGOs to reach out to communities as partners (also known as co-researchers or critical friends) rather than as resources to achieving the sustainable development agenda. The PAR methodology, in the perspective of the researcher is a flexible approach to sustainability science as it offers both quantitative and qualitative tools to be applied, as such fits the transdisciplinary areas of sustainable community development.

For academics, dilemmas arise in the use of PAR because it is time consuming and unpredictable, unlikely to lead to a high production of articles in refereed journals and its somewhat "messy" nature means it is less likely to attract competitive research funding. Acceptance of PAR as a legitimate research methodology will require change from sustainability journals, funding bodies, and universities in the way that they judge research performance. There must be an emphasis on real-life experiences in research, and the ability of a researcher to bring about real change to the quality of life and sustainable development must be taken into account.

7 Conclusion

Based on the application of the PAR method in sustainable community development research in Pulau Mantanani, it is evident that the PAR approach exemplifies a stark contrast compared with the traditional research model. In a traditional research model, the researcher would be required to compile and collect data and information aimed at presenting empirically-based responses which later provide the basis for recommendations and decision-making especially for policy makers, and NGOs. If the research on sustainable community development involves determining the facts in a given geographic boundary, the application of the traditional research model provides scientific legitimacy and provides valuable information to sustainability practitioners. For a PAR researcher, the traditional research approach may be lacking in rich data and information. Often a PAR researcher, who is studying the process of sustainable community development is curious about the elements that are critical to facilitate the process of social change within a community. As such the traditional research model albeit the empirical advantages, lacks in its capability to generate in-depth knowledge or for determining the course of social change in a community.

In a traditional research model, the researcher typically adopts the dominant role in shaping decision-making. The focus is on the traditional researcher to describe and analyse the behaviour of the subjects of inquiry (e.g., respondents) as it would occur without the researcher's presences. In this case, the subjects of inquiry are only require to promote the needed information to the researcher, and often the respondents lack a feeling of ownership especially in decision making. In a traditional research approach, the dependent position of the subjects reduces their possibilities of continuing to learn from the process. On the contrary, a PAR researcher would take the approach of collaborating with the subjects of inquiries (e.g., community members) to co-learn and mutually inquire about the issues of concern and develop the proposed decisions jointly. A PAR researcher would combine participant observation with explicitly recognized action objectives and a commitment to carry out the project with the active participation in the research process by some members of the organisation studied.

From the researcher's point of view, the PAR approach brings about opportunities to conduct development and facilitate social change within communities. Based on the case study in Pulau Mantanani, the PAR methodology demonstrated both values and limitations as a research approach in sustainable community development. This paper also demonstrated that the PAR methodology provided the development actors with an inclusive and robust process for communities to explore their own practices, to define and agree to a consensus on actions or interventions to initiate a social change, and eventually empowered to take actions to improve their livelihoods.

Compared to the traditional research approach, the PAR methodology truly reflects inclusivity of all the relevant development actors. In all future studies of sustainable development, and with the Sustainable Development Goals in place as a guide to sustainability for all countries, the PAR method is a research approach that brings out the stories of vulnerability in communities and empowers the same people to address it. The value of vulnerability is immense and provides the researcher with an insight that can assist in identifying elements to address and reduce the vulnerable elements within a community to attain empowerment. This provides PAR with the benefit of yielding richer knowledge and information that can bring about transformation in communities especially vulnerable and at-risk communities. A traditional researcher may rely on the hardware and software approach of sustainable community development, on the other hand, a PAR researcher brings richness to community development research as it adds the dimension of "heartware" into the equation of sustainable development. In the opinion of the author, the "heartware" of community development is often less explored and understood yet forms the basis of all development efforts towards sustainable development.

The concept of "leave no one behind" as emphasized by the SDGs illustrates the need for community involvement in all sustainable community development efforts. For inclusive community involvement to be incorporated in any development interventions would require the inclusion of a process, be it a research-based approach or a development-based approach, in which provides the opportunity for the community's voice, vulnerabilities, ideas, vision, dreams and expectations to be heard, respected and included in future interventions. From this case study, the PAR approach in intervention planning, development and implementation for sustainable community development demonstrated that the PAR method is a valuable empirical research process that is able to facilitate a more accurate and authentic analysis of social reality in the areas of sustainable development. As the Sustainable Development Goals contain various social components that are critical to address in facilitating sustainable development, it is hoped that the results of this case study contribute to strengthening the case for the adoption of PAR methods in future areas of sustainable development studies.

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Post-occupancy Evaluation Focused on Accessibility: Experience of Participation in the University Community

Adriana Gelpi, Rosa Maria Locatelli Kalil and Wagner Mazetto de Oliveira

Abstract University campuses are the main places where the activities of higher education are developed. To include students, teachers and the community in this educational space it is necessary to have accessibility in open areas and buildings. The access routes, the pedagogic environments of the campus and the coexistence of administrative, educational and recreational activities should allow the free circulation of pedestrians and people with disabilities or reduced mobility. The inclusion and permanence of young people and adults in university environments is a fundamental strategy to raise the level of education of the population, contributing to achieving the Sustainable Development Goals. The paper presents a post-occupancy evaluation focused on the physical accessibility in an institution of higher education. The methodology procedures include photography record, surveys, walkthroughs, and interviews with the university community. The preliminary results show that the implementation of accessibility in university campuses still needs to raise awareness on universal accessibility and urban democracy. The participation of the university community is essential for the implementation of accessibility as a strategy for social and environmental sustainability, preparing professionals to face challenges of cities and committed to the environment.

Keywords Higher education · Persons with disabilities · Lifelong education · Accessibility technical norms · University campus

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1 Introduction

The right to higher education is important in developed countries since the last century. However, historically, higher education has often been inaccessible to groups such as women, ethnic and racial minorities, the disabled and the poor. The UN international agencies and agreements endorse this right, seeking to extend it more and more to the populations of all countries, initially in the Charter of the United Nations of 1945 (United Nation 1945). The International Covenant on Economic, Social, and Cultural Rights of 1966, recognize the right of everyone to education directed to the full development of the human personality and the sense of its dignity and shall strengthen the respect for human rights and fundamental freedoms. Thus, the higher education shall be made equally accessible to all, by capacity, by every appropriate means, and in particular by the progressive introduction of free education (United Nations 1966).

This condition is reinforced in conferences, conventions, and agreements on sustainable development established by UN member countries since the 1990s. In 2015, Agenda 2030 has established 17 Sustainable Development Goals and 169 targets endorsed by 193 countries. The vision of these goals and targets "envisage a world free of poverty, hunger, disease, and want, where all life can thrive; envisage a world free of fear and violence; a world with universal literacy; a world with equitable and universal access to quality education at all levels, to health care and social protection, where physical, mental and social well-being are assured" (United Nations 2015).

SDG 4 specifically focuses on education*: Ensure inclusive and quality education for all and promote lifelong learning*. This goal affirms that obtaining a quality education is the foundation for improving people's lives and sustainable development. Both the right to education for all people and the right to higher education with universal accessibility are present in the goals for 2020 and 2030.

Concerning Goal 11: Make cities inclusive, safe, resilient and sustainable, expressing that the challenges cities face can be overcome in ways that allow them to continue to thrive and grow while improving resource use and reducing pollution and poverty. The future includes cities of opportunities for all, with access to basic services, energy, housing, transportation and more.

As the providers of higher education, universities can directly contribute to the realization of SGD 4 and its targets and of the others SGD that concern with education and sustainability, as seen in Table 1.

2 Education and Accessibility

For the right to education to be possible, including the right to higher education, it is necessary to build, adapt and maintain educational establishments that allow access for all, including people with disabilities due to handicaps or reduced mobility. In dealing with accessibility, the UN presents the guidelines and suggestions for envi-

Table 1 Targets concerned with education right for all in SDG 4 and 11

SDG 4	**Ensure inclusive and quality education for all and promote lifelong learning**
4.3	By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university
4.5	By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples, and children in vulnerable situations
4.a	Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, nonviolent, inclusive and effective learning environments for all
4.b	By 2020, substantially expand globally the number of scholarships available to developing countries, in particular, least developed countries, small island developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programs, in developed countries and other developing countries
SDG 11	**Make cities inclusive, safe, resilient and sustainable**
	By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities

Source United Nations (2015)

ronments without barriers, "Accessibility for the Disabled: A Design Manual for a Barrier Free Environment". The publication guides architectural and urban design aspects to accessible design, including educational buildings. The urban design considerations present guidelines for obstructions, signage, street furniture, pathways, curb ramps, pedestrian crossings and parking (United Nations 2003).

More recently, the states parties signed the United Nations Convention on the Rights of Persons with Disabilities. The measures include the identification and elimination of obstacles and barriers to accessibility, applied to buildings, roads, transportation and other indoor and outdoor facilities, including schools, housing, medical facilities, and workplaces. The convention recognizes the right of persons with disabilities to education, without discrimination and by equal opportunity. States Parties shall ensure an inclusive education system at all levels and lifelong learning; ensure that persons with disabilities can access general tertiary education, vocational training, adult education and lifelong learning without discrimination and on an equal basis with others; ensure that reasonable accommodation is provided to persons with disabilities (United Nations 2007).

3 Brazilian Policies on Accessibility in Education

In Brazil, there was the incorporation of accessibility policies from the Federal Constitution of 1988; it defines “the law shall determine norms of construction of public places and buildings of public use and manufacturing of public transportation vehicles, to guarantee adequate access for disabled people” (Brasil 1988). In 2000, Laws 10.048 and 10.098 also established different treatment, general norms and basic criteria for the promotion of autonomous accessibility of disabled people to buildings, urban spaces, urban furniture, and equipment. Both were regulated by Federal Decree 5.296 of December 2nd, 2004 (Brasil 2004), with deadlines for the adaptation of buildings to the technical norms of accessibility of NBR 9050 2004 (ABNT-Associação Brasileira de Normas Técnicas 2004).

In 2008, the National Policy for Special Education in the Inclusive Education Perspective was introduced with the proposal of inclusion from the earliest years of higher education. This legislation follows the guidelines of the United Nations Convention on the Rights of Persons with Disabilities, which was incorporated as a constitutional amendment in Brazil by Decree no. 6,949/2009 of the Civil House (Brasil 2009).

The consolidation of the individual and social rights of persons with disabilities in Brazil had as its most recent legislation the Statute of Persons with Disabilities in 2015. The document aims to ensure the rights, promote equal opportunities, give autonomy and guarantee accessibility in the country. Regarding education, the document advocates that “education constitutes the right of the disabled person, ensuring an inclusive educational system at all levels and lifelong learning to achieve the maximum possible development of their talents and physical abilities, sensorial, intellectual and social, according to their characteristics, interests and learning needs.” It also ensures access to higher education and professional and technological education in equal opportunities and conditions with other people (Brasil 2015).

4 Post-occupancy Evaluation in University Campus

University campuses are privileged spaces for higher education, serving as living laboratories for sustainable development and multiplier experiences. According to the document of the Decade for Sustainable Education, higher education has a specific important role to play. Universities should function with places of research and learning for sustainable development and as initiators and poles of activities in their communities and nationally (United Nations 2005).

Therefore, it is the social responsibility of leaders and the academic community to provide suitable places for all people to attend various activities of teaching and research in higher education institutions. The regulatory departments of higher education in each country establish guidelines for the operation and organization of university environments for new and existing buildings and university campuses. In

Brazil, the accessibility requirement is exercised by the Ministry of Education and by the state and municipal secretariats.

To verify the adequacy and performance of built environments, post-occupancy evaluation (POE) has been increasingly used to diagnose the operating conditions of higher education establishments. Numerous methods are available to efficiently and accurately measure the performance of a given building. Although there is no defined approach to POE, and the methods selected should be decided upon based on the unique needs and objectives of those conducting the evaluation. Review study carried out in the UK pointed out POE methods which can be applied to Higher Education buildings in several emphases (Rilley et al. 2010). As an example, specific investigations on post-occupation assessment in university settings address teaching buildings at Harvard University (Horgen and Sheridan 1996); residential buildings at the University of Arizona (Bonde and Ramirez 2015); and an adaptation project conducted at Oregon State University Campus in Portland entitled *OSU Campus Accessibility Survey and Assessment* (Oregon State University 2014).

5 Accessibility as a Requirement in Higher Education

To foster the adaptation of higher education environments to the accessibility and inclusion of persons with disabilities, government departments and university institutions have organized specialized services. The United Nations Enable-Division of Accessibility for the Disabled is part of Division for Social Policy and Development (DSPD) of the United Nations Department of Economic and Social Affairs (UNDESA). Its global mission is to promote the rights and advancement of persons with disabilities within a broad mandate provided by the World Program of Action (1982), Standard Rules (1994) and the Convention on the Rights of Persons with Disabilities (2006), as well as other relevant human rights and development instruments.

In Brazil, the University of São Paulo (USP) created in 2001 a Permanent Commission known as the USP Legal Program, a pioneering initiative that accompanied a historic moment of a struggle for the rights of people with disabilities. Currently, the Program integrates the Center for the Rights of the Pro-Rector of Culture and University Extension (Naoe 2013).

The Incluir Program (*Include*)—Accessibility Program in Higher Education, created in 2005, aims to promote institutional policies of accessibility in the IFES (Federal Institutions of Higher Education), seeking to promote the academic development of students with disabilities or reduced mobility. Among its actions, is the creation and consolidation of more than fifty-five accessibility nuclei (Ciantelli 2015).

6 POE and the Accessibility in Brazilian Higher Education

The post-occupancy evaluation demonstrates to be a continuous and useful tool for the improvement of spaces for higher education. Concerning accessibility, the POE applications, due to include users with physical and visual mobility constraints, collaborate for an adequate assessment that can result in significant improvements in educational establishments and university campuses. Since accessibility is a prerequisite for students' entry and stay, the contribution of this methodology to the right to higher education allows the participation of users, in addition to the work of technicians.

At the Federal University of Rio de Janeiro (UFRJ), a survey of the barriers encountered by a group of students, staff, and teachers with different locomotion or vision difficulties revealed the need for a genuinely inclusive architecture in a university designed for all (Duarte and Cohen 2004).

At the University of São Paulo Campus of Bauru (USP-Bauru), a study identified described and mapped physical barriers, presenting the interventions carried out, from 2001 to 2005. The study focused on the analysis of the architectural conditions of the three campus units, standards of the Brazilian Association of Technical Norms and carried out interventions (Lamônica et al. 2008).

Aware of this importance of the accessibility, the Federal University of Paraíba (UFPB), linked to the Ministry of Education (MEC), develops the project "UFPB para todos: eliminando barreiras" (UFPB for all: removing barriers). The project aims to conceive an architectural design of an accessible route to UFPB's campus I, and execute a pilot stretch of this route. The pre-projectual phase by understanding the needs of this campus' users, through the concepts of ergonomics and universal design. After field surveys, projective guidelines have been defined, which will contribute to the final project's quality, so that this is not a simple application of the rule, but works free of segregating barriers (Costa et al. 2012).

Physical accessibility at the Federal University of Pará (UFPA) considered the locomotive experience of a wheelchair student. Group of students and teachers identified the main physical and architectural barriers present in the Guamá University Campus based on the application of the official normative instructions for accessibility. They concluded that full compliance with accessibility norms is one of the factors that make possible inclusion in higher education with quality and dignity (Costa and Souza 2014).

Research carried out in the school library of the Federal Institute of Rio de Janeiro Campus Paracambi-RJ, in 2017, from the perspective of Law 13,146/2015 and the Brazilian technical norm NBR 9050: 2015, regarding architectural, urban and instrumental aspects. It concludes that the study of accessibility by indicators can be a useful decision support tool for library managers because it allows establishing criteria of priorities in processes of changes in favor of accessibility (Diniz et al. 2017).

7 Universal Accessibility on UPF Campus

At the UPF, the concern with accessible routes on campus began in 2014, when the superior administration understood the importance of the adequacy of the campuses spaces to the new demands cited by the City Statute, the MEC Guidelines, and standardization. To do so, it would be necessary to meet the legal and social requirements regarding universal accessibility, the democratization of spaces for public use and democratic teaching in HEIs, responding to guiding principles for the design of an accessible route. The Laboratory of Urban and Regional Studies (Laburb) was asked to analyze the Campus I to adapt the urban space and buildings for accessibility. The initial project work resulted in research on universal accessibility in educational institutions, focusing on UPF Campus I in the city of Passo Fundo, State of Rio Grande do Sul, south of Brazil.

The central campus of Passo Fundo University is a regional educational reference, bringing into it vehicles from many towns of northern RS, from automobiles, buses, and bicycles, besides vehicles for supply and load. Due to all these characteristics, this campus becomes a reference as an educational institution in the state, with around 14 thousand students, considering that 26 present disabilities (visual, hearing disabilities and wheelchair users). Counting on greater access and demand of students for college education and to the system of campuses of UPF, it came up the need for adapting spaces to the new demand of XXI century, City Statute, Guidelines of MEC and universal accessibility. It lacked more significant attention to several legal and social requirements with relation to accessibility and democratization of public spaces and democratic teaching in the institution from these guidelines.

8 Methodological Research Procedures

To implement accessible routes on campus, the UPF Campus I Universal Accessibility Pilot Project was designed as part of the campus's sustainable urban mobility, including the adequacy of roads and public spaces, the adequacy of rides and access to buildings and adapting the transport system to the principles of universal accessibility.

The methodological steps included: (1) Bibliographic review of the universal accessibility standard, legislation, and reference bibliography; (2) Case studies of accessible spaces in university campuses and urban areas; (3) Diagnosis of accessibility and urban mobility of Campus I; (4) Elaboration of urban design and detailing of infrastructure models for accessible routes, sidewalks, ramps, bus stops, road crossings; (5) Research of construction materials to adapt the campus to the proposed models; (6) Work together with the team of the construction sector to adapt the designed models to the physical, structural, technical and financial feasibility conditions. (7) Post-occupation evaluation of the adapted routes.

8.1 Diagnosis of Mobility and Accessibility of Campus I

The diagnosis of urban mobility and universal accessibility of UPF's campus I was carried out in 2015. UPF's Campus I receives vehicles from several municipalities in the north of RS, from cars, buses, and motorcycles, as well as cargo vehicles. The current access to the campus is located next to a federal highway with intense traffic. Internally there is a priority for the displacement of motor vehicles; little space for pedestrians, with narrow streets, few routes and open spaces accessible, wide vehicular paved roads.

The buildings are scattered, distant from each other and connected by walks damaged by the aggression of the roots of the abundant vegetation of flower beds and landscaped gardens. The cobblestone paved streets were tortuous, with discontinuous, nonexistent, or broken parts. The precarious bus stops did not meet the basic conditions required for universal use and accessibility. There is precarious or nonexistent signaling for vehicles with special needs.

8.2 Accessible Route Design

The accessible route was based on the universal design of paths with principles of safety, rationality, practicality and user-friendliness, sustainability and economic viability. The following scope were developed: (a) Design of adaptation of roads, walks, parking lots, intersections, access to free areas and others; (b) Projects of specific points and areas to adapt to universal accessibility; (c) Design or adaptation of accessible urban furniture; (d) Architectural design of access to buildings and open areas; (e) Architectural design of internal adjustments in existing buildings; (f) Accessible route pilot project; (g) Follow-up of the adaptation works on Campus I.

In the execution of the infrastructure accessible in 2015 and 2016, adaptations were made, since the costs of implementing a route with standard dimensions were considerable, due to adjustments and also the extension of the routes. The tactile tiles, composed of colored concrete plates with relief signaling needed to be embedded in sidewalks paved with basalt stones. For that, hundreds of meters of stones were cut, fitting and placed the tactile tiles reference signal with the indication of floors of continuity and alertness. The crossings were raised with asphalt primer. Existing bus stops have been relocated, upgraded and adapted to universal accessibility criteria in Fig. 1.

9 Results and Discussion of Post-occupation Evaluation

The process is still being implemented due to the dimensions of the campus, and to follow up the work, participatory post-occupation evaluation procedures were sought

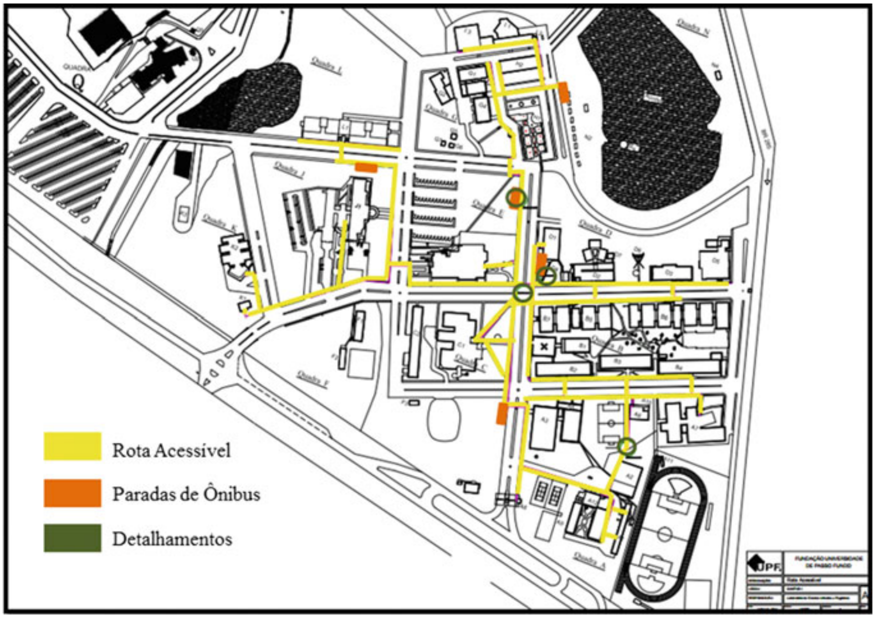

Fig. 1 Accessible route on Campus I of UPF

to collect users' opinions about the accessible route and other elements. Online questionnaires, walkthroughs, and interviews with the community were applied to verify if the proposal meets the real needs of the users.

9.1 Results of Campus User Survey

The questionnaire technique was performed online, in October 2017, and was made available to all students, teachers, and staff of the institution. The questionnaire was composed of twelve objective and discursive questions, addressing the characteristics of respondents and their opinions and knowledge about mobility, accessibility, accessible routes and adaptations made on campus. The questionnaire was answered by 234 people, 63.3% female, and 36.7% male. Of the respondents, 17.5% reported having people with disabilities in the family and 29.5% disabled people in their course, a result that shows that the interest in responding may have been motivated by having people with disabilities in their family and course.

On the place of origin or dwelling of the respondents, 72.65% live in Passo Fundo, 6.84% in Carazinho, 3.42% in Marau, 2.14% in Lagoa Vermelha, 2.14% in Tapejara and the rest in municipalities of the region. About the age group, people aged between 20 and 24 (24.79%) predominated, who are characteristic of university undergraduate

Table 2 Age range of survey respondents

Age range	Responses	
17–19 years	13.68%	32
20–24 years	24.79%	58
25–29 years	11.54%	27
30–34 years	13.25%	31
35–39 years	10.68%	25
40–44 years	8.55%	20
45–49 years	8.12%	19
More than 50 years	9.40%	22
Total		234

Table 3 Schooling of survey respondents

Levels of schooling	Responses	
Complete high school	1.28%	3
Undergraduate courses in progress	45.30%	106
Undergraduate	8.97%	21
Specialization/MBA in progress	4.70%	11
Specialization/MBA	11.97%	28
Master's Degree in progress	3.85%	9
Master's Degree	13.25%	31
Ph.D. in progress	2.99%	7
Ph.D. completed	7.69%	18
Total		234

students, and respondents up to 30 years make up half of the respondents, according to Table 2.

About schooling, the majority of respondents are graduating (45.30%), followed by respondents with a master's degree (13.25%), according to the Table 3.

Regarding knowledge about accessibility and its relationship with citizenship and infrastructure, the answers were conceptualized on a scale of 1 to 5—1 = not knowing and 5 = knowing enough about the theme. The results indicate the concentration in 5—know enough (in four questions) and know a lot (in one question). The averages of the answers to the questions were concentrated above 3.5, indicating that the respondents are aware of the issue of accessibility Table 4.

As for the degree of qualification of the accessible route implemented in the Campus, the answers concentrated in Good, with the average between 3 and 4 in all the questions. The result indicates a degree of qualification with a positive trend. In the sum of the Good and Very Good responses, they were higher than 55% in all evaluated items Table 5.

The results demonstrate a reasonable degree of knowledge and interest about accessibility by the students of UPF I campus. However, depending on the number

Table 4 Degree of accessibility knowledge

On a scale of 1 to 5—with 1 = not knowing and 5 = knowing enough about the subject—indicate your degree of understanding about the issues presented below												
	1		2		3		4		5		Total	Average
Do you know what universal accessibility means?	5.13%	12	14.53%	34	28.21%	66	*29.91%*	*70*	22.22%	52	234	3.5
Do you know what it means to be a disabled person (PcD)?	3.42%	8	5.13%	12	12.82%	30	32.05%	75	*46.58%*	*109*	234	4.13
Do you know that democracy and citizenship are linked to urban accessibility?	3.42%	8	6.84%	16	21.37%	50	25.21%	59	*43.16%*	*101*	234	3.98
Do you know that to have universal accessibility, do you need an adequate infrastructure? (roads, sidewalks, crossings, ramps)	1.71%	4	3.85%	9	5.13%	12	28.21%	66	*61.11%*	*143*	234	4.43
Do you know what a tactile tile floor is?	11.54%	27	6.84%	16	10.68%	25	23.08%	54	*47.86%*	*112*	234	3.89
											100%	234

Table 5 Degree of qualification of the accessible route implanted in the Campus

In what way would you qualify the accessible route deployed on Campus?														
Rated item	Too bad		Bad		Regular		Good		Very good		Unknown		Total	Média
Ramps	3.85%	9	5.98%	14	28.63%	67	*41.88%*	*98*	14.53%	34	5.13%	12	234	3.6
Bus stops	5.98%	14	9.83%	23	27.35%	64	*36.75%*	*86*	10.68%	25	9.40%	22	234	3.4
Tactile floor	3.42%	8	4.70%	11	17.09%	40	*38.46%*	*90*	26.92%	63	9.40%	22	234	3.89
Security tracks	4.70%	11	5.56%	13	15.38%	36	*40.17%*	*94*	31.62%	74	2.56%	6	234	3.91
													Total	234

of respondents, the questionnaire will be repeated in 2018 and the following years, both online and in person, because awareness is a permanent process. At the same time, the rotation of students and campus goers requires lifelong and continuing education to remove physical and attitudinal barriers to access and permanence of persons with disabilities in higher education.

9.2 Results of the Walkthrough with the Visually Impaired

The guided walkthrough to verify the accessibility of the visually impaired was carried out in January 2018, with a group of thirteen people. It was compounded with four architects of the Architecture and Urbanism course (Laburb), a project engineer, two professionals from the service sector student (Saes), an instructor; two visual disable people and blind people members of the Association of Passo-fundense Blinds (Apace). The external route was carried out in an accessible route of about 500 m, in the central area of the campus, from the sports gymnasium to the student service center, according to Fig. 2. The internal walkthrough was carried out in the Coexistence Center and the Student Assistance Center.

The evaluation involved ease walk, bus stops, the condition of the external floors, internal and tactile tile floor, the high crossings of the rails, the ramps, the tactile signaling totems, the accesses to the toilets and the commercial and service spaces.

01 – Sports gym 02 – Coexistence Center 03 – Student Assistance Center

Fig. 2 Walking walkthrough conducted with visually impaired

Visually impaired people used blind walking sticks or support from companions. Based on the photographic record and the comments of blind and visually impaired visually impaired people and their accompaniments. Table 6 shows the results related to the external route and Table 7 the internal route ones.

Next, an interview was conducted with the focal group, with eleven questions regarding the evaluation of the accessible route and the adaptations obtained in the accessibility and autonomy, as well as the recommendations for its improvement. The respondents considered that there was a significant improvement in their autonomy, agility, and independence with the implantation of the accessible route. Adaptation is changing posture and retraining pedestrians and vehicle drivers for enormous respect for the visually impaired. There was the reduction of accidents and more comfortable orientation, helping in the design of mental maps for everyday use. However, even so, the adaptations are not complete and should be improved, although they have been designed and executed by Brazilian technical standards. Based on the transcription of the responses and comments, the interviewees highlighted the aspects of Table 8.

Evaluations of walkthrough and focus groups will continue with groups of the visually impaired and also with groups of physically disabled and deaf people. Also, focus group interviews will be conducted with managers, teachers, staff, and students, as well as reports on the results of the activities.

10 Limitations and Constraints

The post-occupation evaluation activities are still incomplete, so the results are partial. The post-occupation evaluation process takes time and dedication. To reach the majority of the university community should be developed on an ongoing basis. Thus, each year will be planned activities that aim at both the evaluation of spaces adapted or to be built, as well as the awareness and proposition of activities to support people with disabilities.

As UPF has a sizeable central campus, investments are very high and will be made as resources are available. In addition to Campus I, seven campuses must be adapted, with different needs. However, the pilot experiment carried out indicates procedures that have proven positive, as well as restrictions that should be remedied.

UPF has several professionals specialized in the area of accessibility and inclusion, such as urban planners, engineers, physical educators, physiotherapists, social workers, psychologists, pedagogues. They could be called to contribute to the transformation of the university campus and the empowerment of people for attendance, acceptance, and permanence in higher education.

Table 6 Evaluation of the accessible external route for the visually impaired

Rated item	Positive aspects	Negative aspects
External route		
Continuous accessible route	Existing route	Gaps in guide and alert tracks Gaps in signaling Gaps in access to buildings Conflict with drainage Longer courses
Tactile floor tiles	Existing	Inadequate scaling Conflict between floor guide and floor alert
Bus stop		
Floor alert and guide	Existing	Indefinite stop marking on the accessible bus door Incomplete guide thread for all directions
Signaling for PcD		No tactile map No sound signaling
Waiting seat		Nonexistent
Sidewalks routes		
Sidewalks	Adaptation performed on at least one side of the road	Narrow in many points Roughness and Holes Tactile floor on only one side of the track Trees without alert floor tiles Gaps in guide and alert floors Layers on the sides Presence of debris
Pedotactile floor		
Guide pedotactile tiles floor	Existing	Very narrow strips for use with cane Low and spaced protrusions Rugged sidewalk conflict Gaps in continuity
Alert pedotactile tiles floor	Existing	Incomplete Bands Low and spaced protrusions Rugged sidewalk conflict Small dimensions and conflict with floor type guide
Track colors	Tiles in yellow color suitable for dark colored sidewalks	Low color contrast with sidewalks
Ramps		
Inclination	Suitable for general	Conflict with sides Lack of guardrail and handrail

(continued)

Table 6 (continued)

Rated item	Positive aspects	Negative aspects
Alert tactile tiles floor	Existing	Gaps in vehicle accesses Gaps or lack of barriers such as trees and poles
Guide pedotactile tiles floor	Existing	Conflict with access to vehicles Gap on ramps
Elevated road crossings		
Asphalt Flooring	Suitable	Discontinuity on ramps Existence of barriers for vehicles without alert floor
White security strip	Existing	Poor contrast due to wear
Signaling for PcD		Nonexistent No sound signaling

11 Conclusions

Accessibility in higher education is directly linked to the sustainable development advocated by the UN Agenda 2030. In this regard, the UPF campus is serving as a living laboratory for the application of DSG objectives and goals that advocate accessibility in Agenda 2030.

The results of the study allow concluding that, although efforts to implement physical modifications in the campus and systems of support to people with disabilities, the work of physical and pedagogical adaptation must be continued and requires the participation of the entire academic community.

As in other university institutions, UPF has verified that even with the implementation of technical standards requirements, environments need to be carefully reviewed according to the real needs of disabled users. Small details that go unnoticed by technicians and other users need to be revised to allow autonomy, free access and ease of locomotion.

The preliminary results show that the implementation of accessibility in university campuses still needs to raise awareness on universal accessibility and urban democracy. The participation of the university community is essential for the implementation of accessibility as a strategy for social and environmental sustainability, preparing professionals to face challenges of cities and committed to the environment.

Table 7 Evaluation of the accessible internal route for the visually impaired

Rated item	Positive aspects	Negative aspects
Internal route to coexistence center		
Marking of accesses	Existing and suitable	
Continuity of route	Existing	Gaps in access to the food court, shops, and toilets Barriers to benches, displays and flower boxes
Guide pedotactile tiles floor	Existing and suitable Good texture and width	Gaps in changes of direction
Alert tactile tiles floor	Existing and suitable Good texture and width	Gaps in access to shops and toilets Internal position in stores to improve
Track colors	Good texture and width Blue color suitable in light floor	
Signaling for PcD		Low signaling
Tactile map totem	Existing	Inappropriate position Little contrast of sign colors Inadequate position of braille signs
Internal route in the student assistance center		
Marking of accesses	Existing and adequate	
Continuity of route		Nonexistent
Alert pedotactile tiles floor		Nonexistent
Guide pedotactile tiles floor		Nonexistent
Signaling for PcD		Nonexistent
Tactile map totem		Incomplete and inadequate position
Interior furniture		No alert marking

Table 8 Recommendations for improvements to the accessible route for accessibility of the visually impaired

Rated item	Recommendations
Continuity of route	Include podotile floor in all routes between bus stops and buildings Fill gaps without podotactil flooring on the routes Try to use the shortest routes
Sidewalks	Use uneven flooring and different texture of the strips
Tracks connection	Provide substantial continuity of the tracks in the corners and access
Pedotactile tiles tracks	Increase the width of the tracks Avoid placement with too close proximity to walls and barriers Use tiles with high protrusions Include guide and warning lanes on stairs, ramps, obstacles, and barriers
Track color	Maintain high contrast with sidewalk floors and environments
Barriers	Placing warning podotactiles around obstacles and barriers, even temporary ones
Elevated road crossings	Maintain contrasting color of security strips Placing a masthead guide and alert floor Maintain difference in pavement floor texture and pavement Remove barriers and obstacles
Ramps and stairs	Connect floor alert with floor guide
Tactile map totem	Inclusion of tactile maps on bus stops Reposicionation the access to buildings and routes Reorganization of signs in contrast color and braille Placement in external and internal strategic points
Sound and tactile map totem	Include near to the bus stops and in the accesses of the buildings
Localization APP	Develop localization application for the visually impaired with a sound description and alert of the routes and accesses of the buildings
Parking lots	Reservation parking lots to PCDs and not interfere with the podotactile bands

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Comparative Analysis of the Environmental Performance of Latin American University Campuses: Methodological Approaches

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Abstract Latin America has megacities and therefore its higher education institutions are challenged to teach and research about sustainable development in very unsustainable contexts such as solid waste management problems. One of the aspects of sustainable development in university campuses is the sustainability in campus operations. Regarding this issue, solid waste management programs (SWMPs) are useful tools that show immediate effects. This chapter presents both a comparative analysis of the environmental performance of Latin American campuses and the monitoring of a particular SWMP by applying case study methodology. This SWMP was implemented at the campus of the Universidad Nacional de General Sarmiento, Buenos Aires, Argentina, in 2013, and monitored for three years. Results showed lack of community participation. This encouraged us to research new strategies and compare this SWMP with other cases in Latin America by using an environmental performance indicator for each university studied. Results showed that the program should be institutionalized, since this would enable the allowance of human and financial resources. Results also showed that communication plans are also relevant tools to improve users' participation. Although these factors were recognized as necessary, they did not guarantee SWMP success because of the poorly structured facilities, limited financial resources and barriers that had to be overcome at individual level.

Keywords Sustainable development · Waste management programs · Environmental indicators · Higher education institutions · Latin America · Case study

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1 Introduction

In the framework of Agenda 21, the United Nations (UN) urged Institutions, Administrations and Governments to implement strategies for sustainable development in their respective areas of intervention (United Nations 1992). In this sense, since higher education institutions (HEIs) are generators and transmitters of knowledge, they should participate in the discussion and analysis of public policies related to sustainable development (Leal Filho et al. 2015), propose topics for debate, and develop tools and criteria of evaluation to achieve the objectives of environmental sustainability, based on their three pillars, i.e. education, research and management (Lozano 2006). In this line of work, initiatives such as the Talloires Declaration (ULSF 1990) and the Copernicus Charter (UEA 1993) stand out at international universities. In 2015, the UN approved the Agenda 2030 on sustainable development, which sets objectives and targets that cover the issue of waste management transversely (United Nations 2015).

At HEIs, one of the aspects of sustainable development is the sustainability in their campus operations (Leal Filho et al. 2015; ARIUSA 2014), and, as key places of learning, research and cultural activity, HEIs have great potential to catalyze changes in the community towards sustainability (Zhang et al. 2011). Some of the most popular initiatives regarding this issue are solid waste management programs (SWMPs). SWMPs seek solutions to solid waste management, an issue becoming increasingly relevant in the urban environmental agenda of cities of Latin America and the Caribbean (LAC), which, due to their high level of urbanization, must develop new strategies to handle increasingly higher amounts of solid waste while spaces suitable for new landfills are becoming reduced due to the expansion of urban and industrial areas (Acurio et al. 2010). These new strategies should certainly point to the objectives of sustainable development of making more sustainable cities and of encouraging responsible consumption and production in their communities (United Nations 2015). Additionally, the inclusion of aspects of sustainability in campus operations may allow improving the environmental, institutional and socioeconomic performance of universities (Zhang et al. 2011). These aspects also provide an informal way of learning about sustainable development through “practice what you preach”, and thus HEIs act as laboratories where knowledge and skills related to sustainability can be developed (Wass et al. 2012; United Nations 2015; Leal Filho et al. 2015). All this implies the use of planning and management tools within the institution, the commitment of the university community, and the development of tools for communication and dissemination of initiatives, since communication not only has the power to inform, but also to inspire and activate a long-term change (Hong 2012).

Sustainable development initiatives at HEIs have had great application in Europe and the United States (Simkins and Nolan 2004), but, in emerging countries, there are few documented experiences and few research results related to this subject, especially in LAC, where the available knowledge remains fragmented and superficial (Wang et al. 2013; Sáenz and Benayas 2011) and where there are no standard indicators of environmental performance at HEIs.

The Latin American Forum of Universities and Sustainability (ARIUSA 2013) proposed steps to follow in the construction of sustainability indicators at universities to evaluate the functioning of the existing experiences. In the same line of work, in Spain, indicators were defined to evaluate the contribution of HEIs to sustainability (CADEP-CRUE 2011). Considering that the indicators should be adapted to the particular conditions of the region where each HEI is located, the RISU project (ARIUSA 2014) defined indicators for the evaluation of sustainability policies at HEIs, but did not define indicators related to the functioning, effectiveness or evaluation of these policies. This exposes the lack of studies regarding the application of systems to measure the performance and monitoring of SWMPs (Karatzoglou 2013).

Based on the above, this chapter intends to make a contribution to address the challenges concerning the monitoring of SWMPs within HEIs through the case study of four Latin American universities. The study focuses on the experience developed at the Universidad Nacional de General Sarmiento (UNGS), Buenos Aires, Argentina, where a SWMP that was developed on the basis of diagnoses with studies of waste characterization (Galván and Bielsa 2012) was implemented in 2013, and monitored during 2014 and 2015. Results of this monitoring showed that the separation efficiency at the origin of the waste decreased from year to year (Faitani 2017). These results motivated us to deepen our studies on the subject of the sustainability of university campuses by comparing the sustainability of four universities of the region.

In the following sections, we present the methodology used to carry out this study, compare the SWMP applied at the UNGS with similar initiatives developed in other Latin American universities (considering three stages as units of analysis, namely development, implementation and monitoring of the SWMP), and estimate indicators that contribute to the institution's environmental performance (Faitani 2017).

2 Methodology

We adopted a case study strategy and, by means of indicators, analyzed the environmental performance of universities with respect to the management of urban solid waste. The case study strategy allows examining and understanding contemporary events, especially for emerging issues (Yin 2005), such as the implementation of SWMPs in LAC (Sáenz 2014; Sáenz and Benayas 2011). The protocol for the case study used here is presented in Table 1 and was adapted from Jabbour et al. (2013). Although the study was carried out in seven university campuses, only four campuses—where full and validated information was available—were selected for this work.

The following requirements were verified in each of these campuses: (i) that they apply environmental management programs that include a SWMP; (ii) that they maintain an active line of work; (iii) that they represent different regions of LAC; (iv) that they are part of university networks; and (v) that their sustainable development

Table 1 Protocol for the research of the case study

Research questions	How did the waste management plan begin at the universities studied? How was the source separation of waste implemented in the campus? How are the results of the implementation of the source separation of waste monitored at each university? Which are the similarities and differences in the implementation of the source separation of waste between the different universities studied? What are the conclusions which may be drawn from this comparison?
Unit of analysis	Implementation process of a SWMP at a university campus
Timeline	The literature review began in 2010 when one of the authors began her teaching task at the UNGS. In 2012, she began to study the implementation of the SWMP. The SWMP was implemented in the campus in 2013 and monitored for three years. The case was analyzed and compared with others between 2016 and 2017
Information sources	The information referring to the SWMP implemented at the UNGS was generated by us, since we promoted the initiative The information concerning the other universities was obtained from documents, such as strategic plans, documents of environmental policy, documents of adhesion to institutional networks, web sites, and works reported in scientific journals (Armijo de Vega et al. 2008; Barros et al. 2013; Buenrostro 2010; Castillo and Luzardo 2013)
Proof of validity	Interviews by mail

Table 2 Universities selected for the study and acronyms of references used

University/faculty	Acronym	Country	Nomenclature
Universidad Nacional de General Sarmiento (Buenos Aires province)	UNGS	Argentina	UNGS
Universidad Nacional de Cuyo (Mendoza province)	UNCUYO	Argentina	UA
Instituto de Ingeniería of the Universidad Autónoma de Baja California, Campus Mexicali	UABC	Mexico	UM
Facultad de Ciencias Físicas y Matemáticas of the Universidad de Chile	FCFM	Chile	UCh

initiatives were promoted by their own personnel interested in environmental issues (Table 2).

For the selection of the indicators to be applied, we took into account the aspects that Zhang et al. (2011) consider crucial in the implementation of SWMPs: (i) to understand how the institution works, especially how the internal decision-making processes are; (ii) to verify the institutional support and commitment as well as the allocation of sufficient financial and human resources; (iii) to maintain adequate communication; (iv) to have infrastructure according to the needs; and (v) to have reliable waste and cleaning operators. We thus adapted the indicators used by Faitani (2017), which consider all the internal actions at HEIs that focus on the benefit of environmental sustainability with a maximum sense of institutional responsibility, promoting the improvement of environmental quality with respect to solid waste management (Faitani 2017).

We applied eighteen indicators, grouped into four categories of analysis referring to the different stages identified in the SWMP implementation process: (i) development indicators; (ii) actual indicators of implementation, (iii) monitoring indicators, and (iv) communication throughout the entire process. Tables 3 and 4 show the indicators with their corresponding scores and the equations for their calculation.

At each stage, for the calculation of the primary indicators, nominal values were assigned according to the particular characteristics of each university. Next, the secondary indicators were calculated by means of Eqs. 1, 2 and 3 (Table 3). Finally, these values allowed obtaining the environmental performance index, defined as the sum of the three secondary indicators (Eq. 4).

With respect to the communication category, first, the primary indicators were assigned nominal values of 1 and 0 to the options "performs" and "does not perform", respectively, and then the communication indicators were calculated according to the equations of Table 4.

3 Results

The processes of development, implementation and monitoring of the SWMP at the universities studied are summarized in Figs. 1 and 2.

The results obtained for the total environmental performance index are shown in Fig. 3, where it can be seen that the UA has the best environmental performance, taking into account the three stages, and that the UCh is the one with the worst environmental performance. The analysis by stages allowed recognizing that they have similar values in each stage, except for the UM in the monitoring stage, which means that the universities studied present strategies and actions at the three stages, whereas the UM has a deficit regarding the monitoring of the plan.

4 Development of the SWMP

At this stage, the SWMPs at the UA, UCh and UM are framed in policies and plans related to environmental sustainability. At the UA, UM and UNGS, diagnoses were made to identify the waste generated as well as its quantity and flow, and the characterization of the waste resulting from these diagnoses allowed determining the different separation categories at each university campus. In addition, at the UNGS and UM, the diagnoses were implemented by activity areas in the campus, taking into account the potential for waste recycling. At the UA, the diagnosis covered the entire campus, quantifying recyclable waste but without specifying the waste categories adopted in the study.

Table 3 System of indicators of environmental performance

Primary indicators	Score	Secondary indicators	Environmental performance index
DI1. Implementation of the SWMP based on the diagnosis with the methodology established	[1-2]	Equation 1. Development $DI = \sum_{i=1}^{i=n} \frac{DI_i}{N}$	Equation 4. EPI $EPI = \sum DI + II + MI$
DI2. Institutionalization of the SWMP	[1-2]		
DI3. Allocation of internal budget	[1-3]		
II1. Personnel, commission or specific office	[1-2]	Equation 2. Implementation $II = \sum_{i=1}^{i=n} \frac{II_i}{N}$	
II2. Areas of application	[1-3]		
II3. Institutional relation with cooperatives of urban waste collectors	[1-3]		
II4. Separation of e-waste	[1-3]		
II5. Minimization of the amount of compostable waste sent to final disposal	[1-4]		
MI1. Monitoring of the SWMP	[1-4]	Equation 3. Monitoring $MI = \sum_{i=1}^{i=n} \frac{MI_i}{N}$	

DI development indicators
II actual indicators of implementation
MI monitoring indicators
EPI environmental performance index
Note i takes the score assigned to each primary indicator and N is the maximal value for each indicator

Table 4 Communication indicators

Primary indicators	Score	Equation 5
CI1. Documents the SWMP CI2. Documents and communicates the monitoring CI3. Interchanges experiences CI4. Trains the staff CI5. Trains students CI6. Massive activities of dissemination CI7. Signaling CI8. Uses of the web, social networks, mails	Performs= 1 Does not perform= 0	$\mathrm{CI} = \mathrm{CI1_i} + \mathrm{CI2}_i + \cdots + \mathrm{CI8_x}$

CI communication indicator
Note i takes the score assigned to each primary indicator

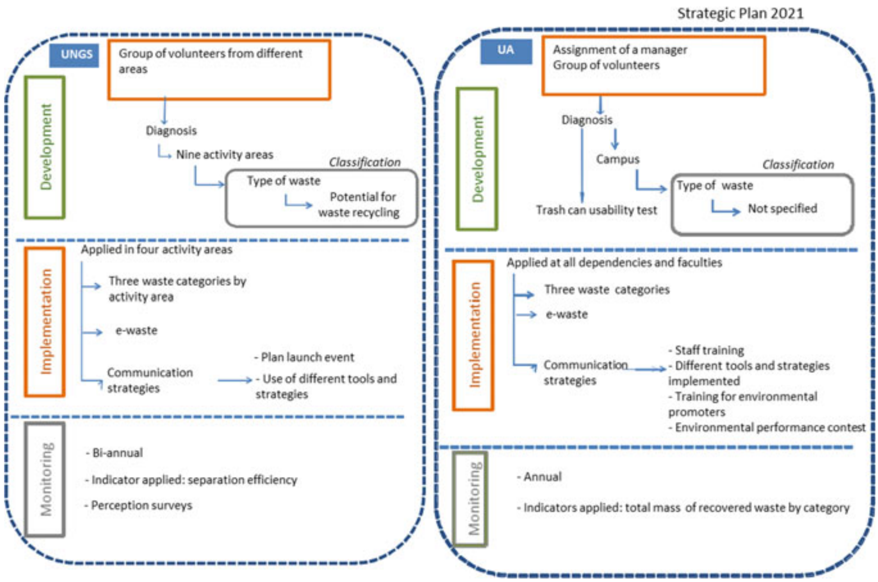


Fig. 1 Summary of the development, implementation and monitoring process at two of the universities studied. Left: UNGS; right: UA

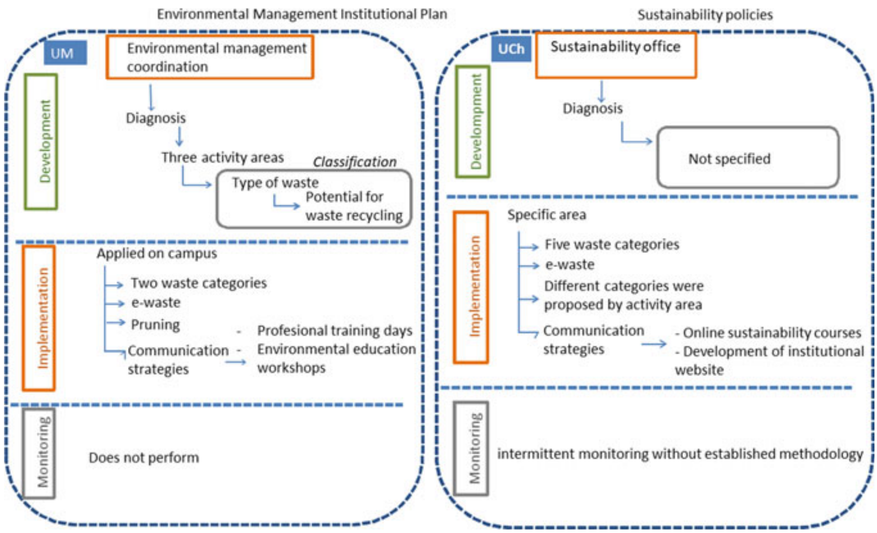


Fig. 2 Summary of the development, implementation and monitoring process at two of the universities studied. Left: UM; right: UCh

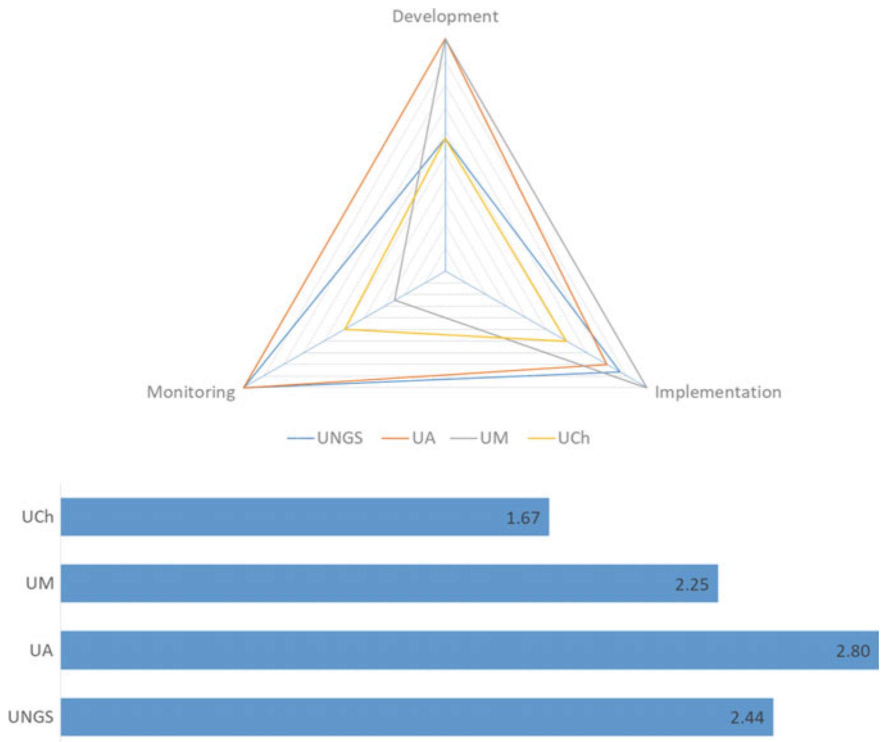


Fig. 3 Up: EPI by stages. Down: Total EPI by HEIs

A trash can usability test, aimed to understand the behavior of users in relation to solid waste management, was also performed at the UA. The UCh did not specify the scope of the diagnosis made.

Regarding the environmental performance for this stage, the UA and UM reached the highest values whereas the UNGS and UCh obtained similar values. In these last two cases, no budget is allocated for the SWMPs. In particular, at the UNGS, the program is not institutionalized.

5 Implementation of the SWMP

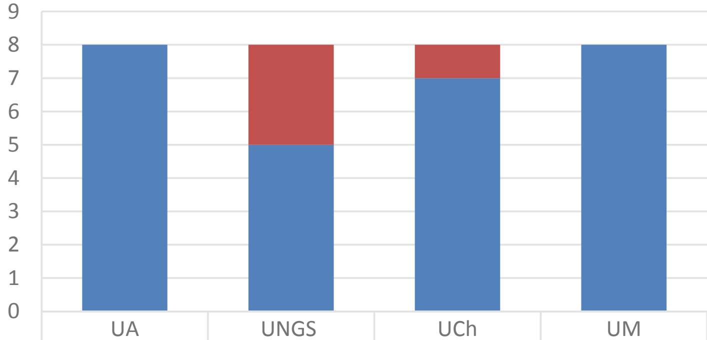
At the UM and UA, the stage of implementation reaches the whole campus (including all the dependencies and faculties), whereas at the UNGS and UCh, the implementation of the SWMP is limited to some sectors of the campus. At the UNGS, the implementation reaches four areas of activity, whereas at the UCh, the SWMP is implemented by only one specific institute.

Within this stage, the number of separation categories varies. The UA and UNGS separate their solid waste into three categories. At the UNGS, these three categories are: recyclable waste, trash, and paper and cardboard, whereas at the UA, the categories are: paper, plastic containers and others (food leftovers, dirty paper, yerba mate and packaging).

The UM separates the waste into the following categories: paper and cardboard, pruning, plastic and aluminum, and inorganic waste. Finally, the UCh separates its solid waste into five categories according to the area of activity: in offices, ordinary hazardous waste (toners, batteries) and paper; in the cafeteria, organic waste; and in intermediate spaces, paper, and aluminum and glass cans. The four universities have in common the differentiated waste management of electrical and electronic equipment, although in their countries there are no legal obligations to separate this kind of waste.

6 Monitoring of the SWMP

The UNGS, UA and UCh carry out monitoring activities, oriented to know the performance of the program, with periodicity and established tools. The indicators associated with this stage (i.e. monitoring indicators) show that the UNGS and UA reach the highest values, because they perform monitoring activities on a regular basis (semi-annually and annually, respectively), and, in the case of the UNGS, by carrying out surveys to know the users' perception of the SWMP. The UCh monitors the SWMP, but does it intermittently and without an established methodology, while the UM does not perform any monitoring activity.



	UA	UNGS	UCh	UM
Does not perform	0	3	1	0
Performs	8	5	7	8

Fig. 4 Indicators for the communication category by each institution

7 Communication of the SWMP

The results regarding the SWMP communication indicators throughout the whole process are shown in Fig. 4.

Regarding the dissemination strategies, they were varied. The UNGS held a launching event, which linked the environmental theme with cultural proposals, such as the development of murals, musical shows, etc. Then, the dissemination strategies of the plan were applied through web platforms and brochures, among others. The communication campaign of the UA included holding competitions related to environmental performance. The UA, UM and UCh have in common the training of diverse actors, such as the personnel, and environmental promoters in the case of the UA. The UM performs conferences and workshops, whereas the UCh offers on-line courses on sustainability at universities.

Regarding the communication indicators, the UM reaches the highest score, followed by the UNGS, the latter of which has no specific staff assigned and no commission or office in charge of implementing the SWMP, and where the application of the SWMP is limited to specific activity areas and not the entire campus, thus decreasing the value of the indicator. In the case of the UA, although it separates the waste in categories, oriented mostly to organic waste, its destination is still the final disposal in landfills. Finally, the UCh has the lowest value due to the limited application of the SWMP (a specific institute), because it does not relate institutionally with cooperatives of urban waste collectors and because it sends the compostable waste to landfills.

The UA maintains SWMP communication strategies at all three stages. Communication activities include dissemination through web sites, social networks, email, participation in radio programs, brochures and posters. In addition, they encourage the exchange of experiences and the realization of massive activities. The fewer communication strategies or aspects at the UCh and UNGS respond to the fact that the UCh do not train students and in the case of the UNGS, it does not train staff and does not document the program.

At the UNGS, lectures were designed for incoming students, with the aim to encourage them to separate the waste. This is an important point because for those who enter university and start a new stage in their lives, waste management is not usually a priority issue as compared with other aspects of university life (Zhang et al. 2011). Likewise, the need to adapt the signaling and periodically reinforce the dissemination of the program are critical points mentioned in various initiatives, since, after making the relevant corrections, the separation results improved (Espinosa et al. 2008). However, at the UNGS, these activities were carried out intermittently and at present are not being carried out because the mechanisms of implementation of such actions require access to certain administrative areas, which is unattainable without a framework that endorses them.

8 Discussion

Here, we studied the environmental performance of university campuses in LAC through the case study of four university campuses that have implemented SWMPs. These programs were analyzed in their three stages of development, implementation and monitoring, and environmental performance indicators were applied to investigate the factors that lead to their success.

Results showed that the UA has the highest environmental performance index, followed by the UNGS, which obtained an index higher than that of the UCh and UM, mainly due to the monitoring stage, while in the communication results, the UNGS obtained the lowest score. This seems to imply that the proposed indicator of monitoring should contemplate the results of the monitoring, indicating the success or efficiency of the program. However, since the monitoring methodologies used by the universities differ, it is difficult to compare the indicators obtained.

At the UNGS, the separation efficiency is determined with respect to the total waste generated, whereas at the UA and UCh the separation efficiency is determined with respect to total annual amounts recovered by category. This way of reporting loses reference with respect to the total waste generated at the institution.

The development of an efficiency monitoring indicator that can be compared between universities also means unifying the measurement methodology, which should be simple and clear. Wilson et al. (2015) proposed the recycling rate, calculated as the percentage of waste recovered with respect to the total generated (including both recycling and composting). Although this indicator was developed for cities, it may be applicable to certain university campuses, since due to their size and diversity of activities they can be considered as small cities (Alshuwaikhat and Abubakar 2008).

Regarding the development, implementation and monitoring of the SWMP, we observed that the diagnostic studies by activity area (Smyth et al. 2010) implemented at the UNGS were adequate to allocate the resources, always scarce, to the areas where it is feasible to improve the environmental performance more quickly. This way of evaluating the amount and composition of the waste allows distinguishing its spatial variation (Felder and Petrell 2001) and understanding the mechanisms and behaviors of waste generation (Baldwin and Dripps 2012; Aderina et al. 2017).

In relation to the destination of the recyclable waste separated by the implementation of the SWMP, an interesting approach is that of the UM, where its recycling potential was determined in the region where the campus is located, i.e. the percentage of waste for which there is a recycling market, because some recyclable waste does not have a local market and transport costs are high.

This approach is interesting because, although from the physical, chemical or biological point of view most of the materials can be recycled or composted, they may not be so from the economic or technical point of view. Likewise, estimating the percentage composition in volume of the waste generated is valuable information to know the particular management needs of each program (Baldwin and Dripps 2012), for example, to determine the space needed for storage and/or number of trash cans that need to be installed.

In the implementation of the SWMPs, the designation of specific areas and the allocation of human and financial resources are also important, as in the cases of the UM and UCh, which have specific areas, and the UA, which has designated personnel. In contrast, the UNGS has no resources allocated to its program. This coincides with the findings of Aleixo et al. (2018a), who suggested that the lack of management and staff support is one of the barriers or obstacles to sustainability in HEIs.

Regarding the dissemination activities, these should also be appropriate for the specific public, taking into account that HEIs should allow non-formal education for sustainability (Aleixo et al. 2018b). The continuity of the initiatives should be guaranteed with a clear and transparent framework, with a defined long-term environmental plan for their institutionalization and with the support of the authorities to achieve the success of the projects (Zhang et al. 2011; Lozano 2006).

Despite the efforts of the UNGS in this regard, the results of the implementation of the communication indicator showed that the institution has shortcomings in communication as compared with the UA, UCh and UM. Both the UA and UM, in addition to activities to exchange experiences and mass communication activities by different means, train staff and users continuously, which is relatively accessible when counting on the appropriate institutional support. So, and in line with that reported by Leal Filho et al. (2015) and Aleixo et al. (2018b), the barriers to overcome during the process of "greening campus" are mainly budgetary, added to the ignorance of how to carry out the process and resistance to institutionalization.

Regarding the dissemination of the results of the SWMP, the case of the UA stands out, because it is an institution that publicly reports all the activities carried out in the framework of the project, from the number of items purchased (trash cans, waste bags) to the number of talks and/or workshops given.

Taking into account the analysis of the indicators by stages and that of the communication category, the UA presents the best environmental performance, followed by the UCh and UM and finally the UNGS.

The development of the indicators proposed is a first approach to evaluate the environmental performance of an HEI applied to waste management and demonstrates the need to build comparable data among LAC institutions where knowledge in this subject is scattered and without standardization.

The development of a common indicator that contemplates the success or efficiency of the program implemented at a university is highly desirable so as to be able to evaluate and compare the processes of environmentalization, to allow the exchange and comparison between them. A common indicator is also important to build the perception of users of HEIs on the problems faced by institutions, since they are quantifiable attributes of the environment and a basic tool to provide environmental information (Gallopín 1997; Aguirre 2002).

Another aspect to be highlighted in this study is that the SWMPs at the university campuses studied have emerged as an initiative from a specific area where stakeholders work in teaching or research in environmental issues, particularly, in waste management.

As mentioned by Lozano (2006), these groups of people are defenders of sustainable development and should thus be identified, involved, supported and be provided with institutional and financial support because they are essential to successfully achieve the environmentalization of HEIs. According to Aleixo et al. (2018b), advances to sustainability can only be made with the engagement of the academic community (rectors, researchers, professors and students) and external entities. In the cases analyzed, the only actors involved were cooperatives of urban waste collection. However, these premises are not always met, because the sole existence of leaders committed to sustainable development does not guarantee the success of the program without adequate financial and human resources support. Likewise, the participation of HEIs in sustainable university networks does not seem to indicate a strong commitment to the objectives of sustainable development. A similar premise is defended by Aleixo et al. (2018a), who claim that there is no strong relationship between sustainable development commitment, implementation of a SWMP and the signing of declarations on sustainable development. In the case of the UNGS, the lack of an institutional framework to sustain the SWMP activities is one of the greatest challenges, while, at the remaining cases analyzed, institutionalization provides stakeholders with the budget and adequate human and financial resources.

9 Conclusions

Based on the results obtained in the present study, we conclude that:

The existence of a regulatory framework that encourages institutions to implement waste management programs is relevant for the incorporation of sustainable development at universities, because it may allow the allocation of human and financial resources, although it does not guarantee the success of the program. However, some barriers related to resistance to changes at the individual level and that have to do with the lack of information, psychological aspects and/or a different system of beliefs, values or needs must be overcome.

Solid waste management programs present the challenge of modifying habits in the community, not only on a personal level (discarding the waste generated in a differentiated manner), but also in the daily work of the institution: installing new trash cans and signs, modifying the internal management of waste, communicating and promoting the initiative, etc. A fundamental aspect in this regard is the allocation of budget and specific personnel to coordinate these tasks.

Developing the initiatives based on diagnoses by area of activity or by analyzing the sources of waste generation is valuable, because it provides a base of information to adapt the proposal to the local reality and recognize that, although it is treated within the same institution, the categories of waste separation may vary according to the area of activity. While this complicates the internal waste management, it can provide better results.

Work on failed experiences of waste management programs can be an opportunity as long as their causes are recognized and analyzed in depth and improvements proposed based on evidence. It is thus indispensable to reliably document the experiences.

Finally, the selection of the case study method and, in turn, the analysis by stages has allowed deepening each case study, making possible the detection of weaknesses and strengths at the university campuses studied. The results obtained after the application of the indicators have shown results that expose the points that must be reinforced to continue the construction of knowledge in this matter.

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PUC-Rio Socio-environmental Agenda: New Steps Towards Sustainability in the University

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Abstract The way towards sustainability for the collective environment of university activities has a crucial role in achieving broader institutional sustainability goals in education, research and projects, both inside and outside university walls, particularly concerning its impact on society. This chapter discusses obstacles and opportunities for the sustainable transformation of the university environment, considering the ongoing process and investments of the Pontifical Catholic University of Rio de Janeiro in the sustainability of its Campus, especially concerning the application of its brand-new Socio-environmental Agenda (an institutional planning instrument built in participatory process over two years). The chapter analyzes the obstacles to implementing the Agenda, regarding (1) governance, (2) teaching and curriculum, (3) research, and (4) projects in all eleven new agenda items, defined as basic topics (water; biodiversity; energy; waste; constructed and living spaces; mobility)

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and crossing topics (education, health, communication, information technology and resilience to climate change). Definition of priorities, governance strategies, continuous monitoring, funding, new applications of technology and resisting inadequate paradigms are some of the obstacles observed, offering contributions to the exchange of good practices for the community of higher education worldwide.

Keywords Education · Sustainability · Socio-environmental agenda · Living lab · Participatory process

1 Introduction: PUC-Rio's Sustainability Project

The purpose of this article is to contribute to the debate about the challenges and opportunities for the implementation of sustainability in Higher Education Institutions (HEI) from the experience of the *Pontifícia Universidade Católica do Rio de Janeiro—PUC-Rio* (Pontifical Catholic University of Rio de Janeiro). The institution values common well-being and holds the search for sustainability as a mission. PUC-Rio has been working for more than seven decades in the production, updating and dissemination of that knowledge which continuously fosters the development of society. PUC-Rio's path for promoting the sustainability of the institution was the creation of the Environmental Agenda in 2009 (NIMA 2009). The University is currently concluding the revision and expansion of the Agenda in the light of the Laudato Si' Encyclical of Pope Francisco (2015), and the debate on Sustainable Development Goals—SDG (United Nations 2015).

The first Environmental Agenda of PUC-Rio is the result of one year of work by the Commission for the Sustainability of the Campus, coordinated by the *Núcleo Interdisciplinar de Meio Ambiente—NIMA* (Interdisciplinary Center for the Environment). An inter-disciplinarily team of teachers, students, employees and volunteers was formed to produce the document that has established a number of actions that enable and promote sustainability at the Gávea Campus of the University, among which are local practices based on humanitarian, scientific and ethical principles, divided into four topics: Biodiversity, Water and Energy; Materials and Waste and Environmental Education.

> The strength and testimony of local actions is extremely important to enlighten and enrich the global proposals for planetary sustainability, contributing to change habits and the process of building new practices (ethos). This is the only way of carrying out the utopia of a world where environmental and social relations are truly more balanced, both for the present generations and for those who will succeed us in the future. (SIQUEIRA, in NIMA 2009, p. 7, authors' translation)

After seven years since the publication of the University's first document for campus sustainability, work for its revision, expansion and updating had started in 2016. Such action was necessary due to the socio-environmental changes that have occurred in recent years, added to new discoveries in environmental science and the publication of the Pope's Laudato Si' Encyclical on Care for Our Common

Home (Francisco 2015), which proposes a systemic, inclusive and trans-disciplinary approach to the ecological crisis that is being faced. Francisco's Encyclical has confirmed the university's belief in the paramount importance of its duty to set the example of responsible behavior regarding social and environmental issues, as well as its social role in leading transformational processes and creating the tools for innovation. Due to the importance given to community inclusion, awareness and experience in sustainability to transform society and to undo unsustainable behavior, Francisco's Encyclical has also inspired even greater emphasis on the participatory process in the concept of the new agenda, as compared to the first one. Furthermore, the agenda has inspired the very definition of new topics, such as resilience regarding climate change and health, which were especially emphasized in the Encyclical.

Therefore, due to the deeper focus on social issues, the new agenda was named the Socio-environmental Agenda of PUC-Rio, reinforcing its importance for strategic action. The Agenda is a powerful management tool that establishes a community pact to consolidate the institution as a sustainable structure, contributing to an effective governance system of the university. It is updated through an inclusive, collaborative and multidisciplinary discussion process.

The work of revision of the Agenda was conceived with the premise of certain primary conditions that guarantee, among other things, community participation with all its diversity and complexity, as well as the space where it is located. Therefore, the structure and content of the Agenda integrates topics with the participation of students and teachers from different backgrounds and reflects urgent issues for society within a vision of the University's potential for innovation.

Based on the assumptions defined above, the Agenda is being organized in seven parts: principles, which guide actions; diagnosis, which indicates the current status of sustainability at the University; guidelines for the set of actions that respond to the diagnosis and meet the principles; goals that detail the guidelines and prioritize the actions; projects that make it possible to achieve the goals; indicators to monitor the effectiveness of actions; and, finally, the creation of monitoring and governance strategies.

Through a collaborative process, eleven topics were chosen to be highlighted in the Agenda, including five from the 2009 document: Water, Biodiversity, Energy, Waste; and Education. Six new themes were incorporated: Health, Constructed and Interaction Spaces; Mobility; Communication; Resilience; and Information Technology. "Basic Topics" (Water, Biodiversity, Energy, Waste, Constructed and Interaction Spaces and Mobility) were worked in separate chapters, although they may be interrelated, whereas "Transversal Topics" (Education, Health, Communication, Resilience, and Information Technology) are designed to have multiple interference with the other issues.

The collaborative and inclusive construction of the Social and Environmental Agenda of PUC-Rio required the use of different methods in four distinct stages. In the first, called the Preparatory Stage, a group composed by 50 volunteers (teachers, students and staff, most of them from NIMA) held meetings for four months to define a work plan and the proposal for the document structure and strategies for its implementation.

The second stage was called Principles, Diagnosis and Guidelines (PDG), which included research scholarship students on the team through an integrated and multidisciplinary scientific initiation project, as well as new undergraduate students, masters and volunteer teachers divided in three working groups. In this phase, much debate regarding PDG with the community of PUC-Rio took place with the participation of about 200 students and teachers during the XXII Environmental Week (EW) of PUC-Rio in 2016. From the meetings held, the "sensitivity diagnosis" surveys and new discussions were conducted.

The third step was called Goals and Projects (GP). At this stage, the campaign for dissemination and the call for collaborative participation was intensified. The virtual participation environment and working groups continued active, as well as the general meeting for discussion of the PDG established in the second stage and the proposal of the goals and projects that occurred in the EW of 2017 (about 200 participants again). The fourth and last step, called Indicators and Monitoring (IM), focused on the preparation of indicators and strategies for monitoring or follow-up of the implementation of the agenda and updating its goals and projects.

In its final format, currently being revised for publication, the Agenda comprises three volumes. The first one is the Social and Environmental Agenda itself, which includes Principles, Diagnosis (summary), Guidelines, Goals, Indicators and Strategies for Monitoring and Governance. The second one presents the portfolio of projects to be executed and managed to reach the goals, according to the collective construction of the community. The separation of this volume from the first one was strategic to guarantee the durability of volume one and to allow for the dynamic updating required for the project portfolio. The third volume is a record of the whole process, acting as the work's calculation memory, including the theoretical discussions, the complete diagnosis and additional information about the whole complementary process to the Agenda.

The collaborative and inclusive work of reviewing and expanding the PUC-Rio Agenda has as its background four fundamental topics: (i) understanding the document as a management tool able to collaborate for effective governance of sustainability in the university; (ii) the importance of a curriculum that addresses social and environmental issues; (iii) the need to carry out and disseminate scientific research on the themes of the Agenda and dedicated to socio-environmental sustainability; and (iv) the development and monitoring of projects related to the sustainability of the campus and collaborate to achieve the established goals. These topics focus specially on the challenges and opportunities of the new PUC-Rio Socio-environmental Agenda.

In order to reach its objective, this article is divided into two chapters and presents a preliminary conclusion regarding the experience of PUC-Rio in the implementation of the sustainability in the campus. The first chapter shows a theoretical review of global concepts and resolutions that surround universities as potential centers for promoting sustainability. The second chapter shows and discusses the obstacles and opportunities found in the implementation of the PUC-Rio Socio-environmental Agenda.

2 Sustainability on University Campuses: A Global Agenda

Aware of its role as a driver of changes in the society and its influence on the breaking of paradigms, the Higher Education Institutions have sought the best mechanisms to incorporate adequate institutional policies and management systems in their physical operations and in their educational system in order to institutionalize their commitment to the sustainable development.

To convert a university into a sustainable environment through the concepts of sustainable development, it is necessary not only to be ecologically responsible, but also economically viable while finding and disseminating solutions for social problems. In order to contribute to sustainable development, institutions of higher learning should consistently foster sustainability beyond their boundaries (Alshuwaikhat and Abubakar 2008).

In pursuit of the ideal way to implement the Global Agenda for Sustainable Development, the HEI have developed their own institutional agendas based on their political contexts, corporate principles and heedful attunement to current issues of local and global society. The HEI are also mainly committed through networking in the academic environment to find sustainable solutions for society, but also through adherence to statements of global scope for sustainability in the HEI, among other forms of engagement (Larrán Jorge et al. 2015). Thus, HEI cooperate to transform society beyond the limits of the university. However, the transformation of the institution itself remains a major challenge.

The true success of an institutional environmental agenda is in implementing its content to reach goals and advance indicators of sustainability, which are the main and most important obstacles to overcome for transforming the university in the sense of social and environmental sustainability. Naturally, institutions will continuously encounter new obstacles and must be prepared to adjust goals and actions constantly within efficient systems of local governance.

One of the issues raised regarding the challenges of implementing sustainability in the HEI is to address the three dimensions of sustainability: ecological, economic and social. Alshuwaikhat and Abubakar (2008) point out that many universities implement measures to protect the environment as initiatives for sustainability; although, the economic and social dimensions are insufficiently addressed. In order to ensure a systemic approach of sustainability in the universities, the authors suggest a management structure that minimizes the limitations of systems focusing on ecological issues and guarantees sustainability through the integration of three strategies: "application of an Environmental Management System (EMS), public participation and social responsibility, and promotion of sustainability in teaching and research" (Alshuwaikhat and Abubakar 2008, p. 1777).

The capacity and governance strategies of the institution will therefore be extremely important to the successful implementation of a local sustainability agenda.

According to Avila et al. (2017): "when a university seeks to implement sustainability initiatives as part of its daily activities, a set of barriers are encountered, which need to be addressed if the proposed activities are to yield the expected benefits" (Avila et al. 2017, pp. 1275–1276) As so, many barriers associated with: management, technology, availability of resources and institutional culture are found and have to be dealt with. Indeed, the capacity for engaging agents within the community is also fundamental. For this purpose, it is central to disseminate information, among other actions.

It is important that decision-makers and the community-at-large see campuses as places of opportunity and areas to foster emerging strategies for managing and deploying appropriate technologies. In an exploratory study conducted by Aleixo et al. (2018) to investigate how the stakeholders of the Portuguese Public College Institutions seize such opportunities, the authors include not only the concept of sustainability, but also sustainability within the HEI and the role of higher education for sustainable development. The study concluded that while leaders, students, management teams and other stakeholders are aware of the concept of sustainability, they are not yet familiar with the concept of Sustainable Universities.

The involvement and commitment of an organization's leadership with a policy or management system is critical to the successful implementation of such tools. The example of leadership facilitates the breaking of resistance of the various silos of an organization and contributes to the adherence of all areas of the institution to new institutional cultures.

Initiatives for transforming environments, inserting new concepts and breaking of paradigms require the involvement of as many actors as possible. The adoption of the participatory process in the construction of institutional policies and in the operationalization of commitments generates greater commitment and legitimacy to the process. According to Disterheft et al. (2015), the participatory process is the key to creating a real community consciousness regarding sustainability and to incorporating it in the culture of the institution. It can also facilitate dialogue, empower stakeholders and increase commitment to the issue.

These processes, which value diversity and multidisciplinarity, often imply difficulties in the need of capacity building and leveling of knowledge among all involved as the first indispensable step of the process. This model of participation, when adopted within HEI, can be transformed into opportunities as the knowledge to be disseminated can be incorporated into the academic curriculum, generating inclusion of the subject in the curriculum and commitment of those involved in the implementation of the developed content.

Bekessy et al. (2007) makes an important remark in stating that, in order for statements to be more than simple promises and the intended results achieved, HEI should adopt a posture of transparency in the processes and developments regarding honorable commitments. Permanent changes can only occur if engagement reaches as many people as possible, not just a small group.

The research done at the Institute of Technology University in Royal Melbourne, described in the article "The failure of non-binding declarations to achieve university sustainability—a case of study" by Bekessy et al. (2007), identified some obstacles for achieving sustainability at the institution, including: (i) the high academic and institutional independency of the units within the university, constraining the need of interdisciplinary approaches to achieving sustainability; (ii) several general financial constraints; (iii) the lack of solid and comprehensive knowledge of sustainability; (iv) and the inadequacy of the built environment.

Therefore, the barriers to change are not primarily financial, as one might imagine, especially in less wealthy contexts. The cultural characteristics of each group and place, as well as the will to change, are equally important.

What is more: a consistent and permanent transformation in a complex structure such as HEI or other collective and institutionalized structure must have its actions and their results constantly measured and monitored. As Adams (2013) points out, regarding the importance of the practice of periodic sustainability reports for institutions that wish to achieve effective transformation, "what gets reported, gets measured; what is not measured, is not managed; and if you are not managing sustainability performance it is difficult to improve it, or know if it has improved" (Adams 2013, p. 385).

The importance of precise indicators that can demonstrate the evolution of the implementation of an Agenda is paramount to generate credibility for the proposed actions and to demonstrate with precision the evolution of the achieved results. Hák et al. (2016) carried out a critical evaluation of the proposed indicators to measure the implementation of the action plan established to achieve the SDG during the process of constructing Agenda 2030 indicator framework in 2015. In this paper, the author remarked that indicators with faulty elements could generate misrepresentation of the results and undermining of the proposed targets for Agenda 2030.

According to Berzosa et al. (2017) the tools for evaluating sustainability may define sustainability strategies adopted and action in the institution. The authors also point out that adequate measurement and monitoring systems and indicators that accurately demonstrate results are useful for leaders to adopt correct strategies and effective actions to seek sustainability, requiring less financial resources.

However, the solid basis for an effective Socio-environmental Agenda is primarily a coherent and accurate diagnosis stage of the current scenario, which indicates the effective level of sustainability of the institution in each aspect of the institution's interest and of the Agenda itself. It is the "V_0" of each topic to be worked by the university to reach sustainability. The projects and goals resulting from this initial assertive evaluation can therefore be given a correct priority and focus on the adoption of more effective actions.

The core activities of HEI are generally teaching, research and academic extension (or the set of forms of relationship with society—individuals, groups, companies and governments). Therefore, in order to achieve a high level of sustainability at the University, it is paramount that these three fields of action are transformed in an articulate way, creating a positive cycle of self-feeding among them. This presupposes the inclusion of sustainability issues in the curricula of professional training courses, allowing them to be updated with the global concern about the durability of the contemporary society and enabling the training of professionals prepared to face the challenge of the global and local social and environmental crisis. It also implies encouraging and investing in sustainability research in all areas, fostering the interest of students in the subject, self-feeding education with innovation in the field and collaborating to find solutions for the university itself in the search for its transformation. It is also necessary to invest in order to the knowledge generated and the professionals trained and acting at the university to reach society through projects, social actions, collaborations, leadership and example.

The Global Agenda 2030, in one of its main approaches, considers educational institutions as key players in the transformation process for sustainable development. From the studies of Weybrecht (2017), the SDG represent an opportunity for HEI in all academic and scientific activities, as well as an opportunity in the campus management to incorporate sustainability. Considering the global scale of performance of Agenda 2030, the author also highlights the opportunity of joining business schools and researchers to work together for change.

According to Alshuwaikhat and Abubakar (2008), due to the educational role of universities, some responsibilities related to sustainability fundamentals can be achieved by incorporating concepts and practices into regular courses, curricula, academic and scientific activities and research.

Another important approach in terms of curriculum and research is the adoption of an interdisciplinary vision to address sustainable development issues. Anna-Diab and Molinari (2017), in a study to demonstrate the importance of adopting the interdisciplinary approach to sustainable development, conclude that “inter-disciplinarity promotes the ability to understand complex problems and act on them, aligned to the expected results from education for sustainable development” (Anna-Diab and Molinari 2017, p. 81).

Many HEI have incorporated curriculum, research, campus operations, community dissemination, evaluation and reports, both the environmental education and the education for sustainable development in their institutional framework. To this end, Ramos et al. (2015) analyzed around thirty-three articles illustrating measures and efforts to contribute to the sustainable environment of universities. These papers discussed not only the implementation of sustainable development, but also the stakeholders’ involvement and participation, the campus operations, sustainability reporting and assessment, organizational change management and curriculum development. The authors conclude that, while there is growing evidence that HEI currently present more “holistic and systemic approaches to sustainability, there are still many challenges, such as better integration of Education for Sustainable Development into curricula, research, and most importantly holistically into their systems” (Ramos et al. 2015, p. 9).

In 2007, the University Kebangsaan Malaysia (UKM) launched two important instruments for the full integration of sustainable development practices at the university by 2020: a UKM Sustainable Letter and a UKM Sustainability Program with the theme “UKM Sustainability for Malaysia and the World”. In parallel, a study was carried out to determine the level of knowledge, awareness, attitude and availability to participate in sustainable development programs. Among the challenges, weak points and obstacles to achieve the university’s goal of having a sustainable campus by 2020 was “to build the capacity for staff to establish and operate a sustainable campus” (Derahim et al. 2012, p. 276). In addition, the administration of the university realized the great importance of strengthening the management system, so that the entire community, inside and outside the university) can feel comfortable inside the campus, thus offering support for the achievement of the objectives.

Another finding that reinforces the state-of-the-art in practices associated with sustainable development, regards the inclusion of SDG in the curriculum, research and communication of institutions. It means that, although HEI leaders acknowledge their importance, such inclusions have not yet been implemented and/or designed. Whereas HEI play a critical role in promoting SDG, and the efforts of their leaders are vital to the achievement of such goals, there is a conceptual challenge for academics in the future: elaborating an interdisciplinary curriculum that allows for performance in projects of sustainability, while, at the same time, guarantees its capacity for employability.

Finally, the success of an institutional sustainability agenda also depends on the capacity to coordinate and implement projects not only conducted within their physical, educational and management structures, but outside such institutions, in the community-at-large and in society, to achieve the necessary transformation as defined by the goals of the agenda. Ideally, these projects will be designed and executed in cooperation with students, teachers, institutional staff and the community, via interdisciplinary teaching, research and extension activities, whenever possible, thereby increasing awareness, community engagement and transformational capacity of measures for institutional sustainability.

3 Obstacles and Opportunities for Implementing the Socio-environmental Agenda of PUC-Rio

PUC-Rio's experience with the 2009 Environmental Agenda (now Socio-environmental Agenda) highlights the interrelationship between the university's capacity of *governance* for sustainability, the incorporation of concern for *sustainability in education*, the production of knowledge in this area (through *research* activities) and the ability to find *solutions* and execute *projects* that increase sustainability *inside and outside the university*.

An example of this interrelation is observed when including different agents in constructing a pact for the sustainability of the university when building the agenda, which is decisive for expanding community awareness and engagement, especially that of students, with whom it had a positive impact—not only on the legitimacy of the management tool, but also on the students' interest in the subject of sustainability in the different areas of knowledge, thereby creating a clear demand for subjects and research.

As witnessed in the Agenda, such a demand has the potential to stimulate and renew the supply of subjects that reflect concern for the environment. The demand for such content, as well as the student movement surrounding proposals of solutions and projects to reach the goals of the Agenda, during the very process of its drafting, has enormous potential to encourage research in the area. This would be focused not only on the sustainability of society, but also on its specific and contextual challenges of the sustainability of the Campus itself. It is the first strong indication of a positive mutual impact among good governance for sustainability, teaching, research and academic extension activities.

The incentive for research in the area of sustainability has already been given by the university's central management, which, for example, awards scientific initiation projects that deal with issues related to socio-environmental sustainability, contributing as an opportunity to the success of the implementation of the Agenda in PUC-Rio.

In addition, the research on campus-based sustainability and its local-specific issues, associated with the growing supply of academic disciplines with the same subject, are the ingredients for the establishment of a living laboratory in the university, or rather, *the consolidation of the university as a living laboratory of sustainability*.

This is another opportunity identified by the process of constructing the new environmental agenda of PUC-Rio in the last two years of work, and it is one of the most emphasized points by the group of students, teachers and staff who participated in the preparation of the socio-environmental agenda.

A living sustainability laboratory, however, is not consolidated in a university with the complexity and solidity of PUC-Rio without overcoming a set of obstacles, among which are the rigidity of the curricula of several courses and the delay in the modification of these curricula—when and if already dealing with any resistance from the teaching staff.

Throughout the process of preparing the Agenda, the Interdisciplinary Center for the Environment (NIMA) of PUC-Rio carried out a survey of subjects related to sustainability offered in the 27 departments of the University. Most courses in this area are elective, i.e., external to the compulsory curricula, and has remains so for years, without being incorporated into those curricula, reinforcing the suspicion of their high rigidity. On the other hand, the fact that 47 sustainability disciplines, distributed among 20 undergraduate programs at the University, were identified in a preliminary survey suggests a strong predisposition for adherence to the topic. A movement that is almost counterculture is certainly a great opportunity. Another positive factor to increase the environmental awareness of students in the classroom was the implementation, in 2017, of the discipline on the topic Socio-environmental Ethics and Human Rights of the Department of Theology, replacing the discipline Professional Ethics in the obligatory curriculum of subjects of Religious Culture of undergraduate programs.

Regarding research, the main obstacle seems to be the adaptation of the obligatory interdisciplinary nature of this topic in the open calls for proposals of local institutions that are still quite strict, as well as the criteria of national evaluation to which the researchers are submitted in the country, according to information provided by several teachers, directly influencing their topic options.

Obviously, the difficulties of fostering interdisciplinary research will be reflected in the promotion and development of the university extension projects. Although internally this can be more easily solved by the institution, the extension of this kind of initiative beyond the structure of the University is essential to ensure the leading role that HEI represent for society. For this purpose, the institution needs not only to exercise sustainability within its structure and influence transformation through example, but also to cooperate with the local community—with the neighborhood, the city—in actions and projects for its own transformation.

However, what is most striking when observing what happens with research in the area is precisely that the same interdisciplinary character which may be an obstacle to its expansion is also a huge potential for PUC-Rio. There is proximity among departments, teachers and students of the different areas as a strong brand, positively boosting the interaction among the areas. This proximity is conditioned by the physical characteristics of the main Campus, in the Gávea neighborhood, but it is reinforced by the institutional guideline of maintaining all undergraduate programs within the same Campus, forcing direct contact among the people of its community. And this vocation is evidenced, for example, by the existence of the Interdisciplinary Center for the Environment, created in 1999, whose main purpose is to gather the wide diversity of knowledge and articulate interdisciplinary actions inside and outside the University, in order to encourage socio-environmental sustainability.

The very formation of the PUC-Rio community is, in itself, a promising opportunity for the successful implementation of the Agenda. The university is community-based and offers some form of financial aid scholarship to approximately 50% of its approximately 12,000 undergraduates. It results in a very diverse student population in terms of social groups, purchasing power, as well as geographical origin, which goes beyond the borders of the country. This diversity is a fundamental ingredient not only for the quality of the Agenda, but also for its implementation, by bringing together different economic and cultural backgrounds, life experiences and experimentation with environmental challenges and previous solutions—knowledge that naturally contributes to the discussions and proposals for the Agenda and its implementation.

The combination of disciplinary plurality and socio-cultural diversity in the construction of the Agenda, which will potentially have a direct impact on its implementation process, proved to be challenging for the priority-setting stage that is central to the effectiveness of the Agenda as an institutional management tool. The discussions held in the seminars and workshops of the XXIII and XXIV Environmental Weeks managed to gather many ideas for the sustainable transformation of the university, projects and dreams that were not consistent enough in the prioritization of actions, a task that was completed by the NIMA team.

In the profusion of ideas and projects proposed by the community in the collective construction of the agenda, the greater emphasis was certainly given to the use of new technologies for sustainability solutions in the ecological aspect, not excluding the direct interference in the economic aspect. Therefore, the themes "biodiversity", "water", "energy", "waste" and even "mobility" and "constructed and interaction spaces" received more concrete and emphatic proposals, such as the recovery and expansion of green areas with ecological function, improvement of the quality and reduction of water consumption, waste management, reduction of consumption and local generation of energy, reduction of the use of automobiles, expansion of areas of permanence, social interaction and study on campus, among others. Although the emphasis on technological innovation has undoubtedly arisen in these areas, which is compatible with its more concrete nature, this has not happened to the detriment of consistent proposals in terms of investment in social capital, reinforcement of collaboration networks, improvement of the interaction environment in order to make it more creative and aligned with the ongoing transformations in the society, associated with the proposals of transformation in the curricula experienced by students in a day-to-day basis, mostly in the collaboration group, thus also emphasizing the "education" theme.

However, more arid and less concrete issues—such as "health", "resilience to climate change", "information technology" and "communication"—were addressed as "transversal" in the Agenda for this very reason—were not excluded from the interest of the community, although the proposals were more moderate. Certainly, these issues are crucial to fostering sustainability in society and in the contemporary context and require special care in the preparation of the Agenda by the institution's technical team, given the lack of familiarity with the community-at-large, demonstrating a challenge to be overcome.

4 Conclusion

The contemporary world is characterized by an unprecedented crisis between society and nature, expressed in the unbridled use of finite natural resources, from unsustainable actions that compromise the services of life support. The Laudato Si' Encyclical clearly shows this contradiction and calls for the citizens of the planet to act locally and globally in a coordinated way to search for sustainable models of coexistence that can assure adequate living conditions for present and future generations.

In this context, universities face a major challenge in their three dimensions: in teaching, research and academic extension. Thus, the scientific effort requires multidisciplinary approaches and different participatory methodologies that generate integral solutions with a sustainable bias. Such research needs to interact and reformulate segmented teaching dynamics with transverse contents that provide students with an integral view of the individual-nature relationship. In the same approach, academic extension gains a new weight in offering concrete and affordable solutions to society by allowing the student and the researcher to consolidate the process of and the commitment to a new paradigm of sustainability in an integrated and multifaceted action.

The example presented by PUC-Rio, which describes the long participative process of consolidating sustainability at the University, clearly shows the dynamics, comprehensiveness and complexity of the agents involved, suggesting the importance of a clear and objective commitment of the University administration, of its teachers and students groups and of its employees, to new concrete and daily actions for sustainability as a goal and challenge for all.

The present study confirms the importance of the instrument used, the review of the Socio-environmental Agenda of PUC-Rio, in order to outline the holistic and multidisciplinary vision that the sustainable management of a university campus demands. The option to use Laudato Si' as a conceptual framework of the process was very promising, as well as the different levels and methodologies of articulation and action such as lectures, workshops, seminars, research projects coordinated by teachers, students and scholarship student of the Institutional Program for Scientific Initiation, were found to be tangible actions with a strong impact on the University as a whole. The organization of the synthesis-document, which mirrors the results of the process, was renewed and expanded, as the guidelines and goals branched out into projects, responsibilities and indicators, as well as the number of topics raised from seven to eleven, in order to incorporate the substantive dimension of humans in the configuration of PUC-Rio's new Social and Environmental Agenda.

In conclusion, the process presented in this article proved to be constructive and evolutionary, capable of stimulating the sustainability of the University, which can be used by other universities undertaking the commitment for transformation, aligning the dynamics to local realities with regional and global scales.

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Vortex-Assisted Liquid-Liquid Microextraction for Steroid Profile Analysis: Towards Sustainable Development Goals 2030

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Abstract Prevention of waste is among of 12 principles in green chemistry. This study discusses about a simple, rapid and environmentally friendly method for the determination of endogenous steroid profile. A vortex assisted liquid-liquid microextraction (VALLME) as sample preparation followed by liquid chromatography tandem mass spectrometry (LC-MS/MS) for the determination of steroid profile in urine was identified. The proposed method fulfilled the green chemistry principle and Goal 13 in Sustainable Development Goals.

Keywords Green chemistry · Microextraction · Steroid profile · LC-MS/MS · Urine analysis · Sustainable development goals

1 Introduction: Sustainable Development Goals

The Sustainable Development Goals (SDGs), otherwise known as the Global Goals, are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. These 17 Goals build on the successes of the Millennium Development Goals, while including new areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice, among other priorities. The goals are interconnected—often the key to success on one will involve tackling issues more commonly associated with another. The SDGs work in the spirit of partnership and pragmatism to make the right choices now to improve life,

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in a sustainable way, for future generations. The SDGs are an inclusive agenda and a clear guidelines and targets are provided for all countries to adopt in accordance with their own priorities and the environmental challenges of the world (United Nation Development Programme).

2 Goal 13: Urgent Action to Combat Climate Change

Climate change is a real and undeniable threat to our entire civilization. The effects are already visible and will be catastrophic unless we act now. Through education, innovation and adherence to our climate commitments, we can make the necessary changes to protect the planet. The importance of education in relation to climate change has been widely reported. In general, education has an important role in limiting the causes and consequences of climate change. Education factors especially for young people can have a positive impact on climate change and extreme events.

Education is important to help people adapt to the consequences of climate change. However, education can also induce changes in the behavior needed to combat climate change. The importance of education on climate change needs to be applied from childhood to ensure that this generation understands the issues and problems that need to be addressed and how to overcome them. In this 4th industrial revolution generation, all parties need to be responsible for addressing climate change as all groups; especially engineers, researchers, scientists, farmers and others contribute to climate change. Hence, awareness and precautionary measures need to be taken to ensure that climate change impacts can be mitigated.

A study by World Bank (2010) shows that students and the public have the wrong perception on various aspects of climate change, greenhouse effect, and the ozone layer. Studies have also found that the information, education and awareness rising has so far been inadequate to stimulate people to act towards reducing the effects of climate change (World Bank 2010). Hence, the proposals for implementing sustainable development education to be applied in the school curriculum and university are highly welcomed. United Nations Educational, Scientific and Cultural Organisation (UNESCO) emphasizes the need for a common framework to increase climate perceptions through education, and to support education as an uncharted strategic resource for building resilient and sustainable societies (UNESCO 2013). The World Bank stated that combining climate change education in the school curriculum is the first step and demonstrated the need for different approaches to providing information on climate change (World Bank 2010). Discussions on climate change have outlined that capacity building to encourage awareness and learning should be involved not only governments but also non-government organisations and large companies, and the role of education in technology and chemical analysis needs to be strengthened in achieving SDG through every method and technology developed. The method developed in analytical chemistry must be guided in achieving SDG goals. The awareness campaign on the impact of analytical chemistry on climate change should be disseminated to students, scientists and related researchers. Furthermore, skills need to be practiced and to enhance knowledge to combat climate change through teaching modules and implement participatory teaching approaches especially in developing a new analysis methodology.

3 Green Chemistry

Green chemistry is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. Green chemistry applies across the life cycle of a chemical product, including its design, manufacture, use, and ultimate disposal. Green chemistry is also known as sustainable chemistry (USEPA 2017). So, in developing a method, a sustainable development or green analytical chemistry should be considered to ensure sustainability for tomorrow. Usually, the goal of green analytical chemistry is to use analytical procedures that generate less hazardous waste and that are safer to use and more benign to the environment (Keith et al. 2007). It is well known that in analytical chemistry most methods employ solvents that can harm the environment in terms of its toxicity and the volume used. So, new sustainable analytical methods are proposed that incorporate procedures that either use less hazardous chemicals or use lesser amounts of hazardous chemicals.

An important part of the green chemistry philosophy is the need to develop and adopt green analytical techniques and procedures. Analytical chemistry takes a special place in the green chemistry concept. It is aimed to detect and quantitatively determine various substances by means of methods which often use harmful reagents. As a result, the analysis itself may become a source of pollution. Analytical chemistry is considered to be a small-scale activity, but this is not always true in the case of controlling and monitoring laboratories such as anti-doping laboratories where a large number of analyses are performed. The use of instrumental methods instead of wet chemistry; the miniaturization and automation are the new trends of analytical chemistry, making this branch of chemistry more sustainable (Koel and Mihkel 2006). The determination of a broad spectrum of analytes at low concentrations (ppb, even ppt) in samples of complex matrix composition has been facilitated by the introduction of a new generation of highly sensitive analytical devices and by the development of new sample preparation procedures. The principles of green chemistry by Anastas and Warner (1998) are shown in Fig. 1.

Most efforts in making chemical processes greener emphasize the need for using safer, less toxic, and more benign solvents, or the elimination of solvents completely, and reducing the use of reagents and auxiliaries. Other strategies include lower energy

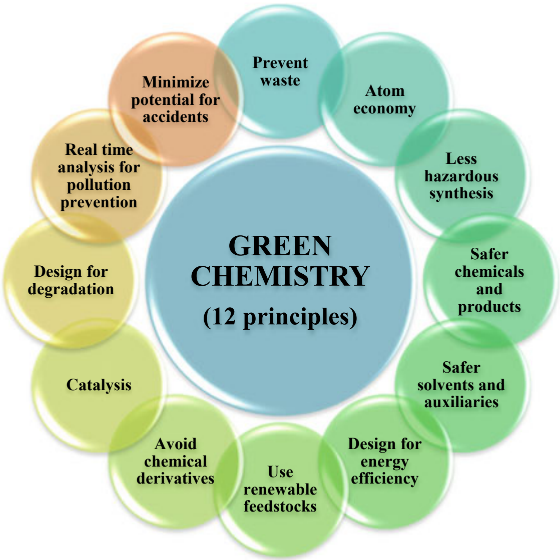

Fig. 1 The principles of green chemistry (Anastas and Warner 1998)

consumption through the use of milder reaction conditions (Rummi 2017), avoiding derivatization and a preference for substrates based on renewable sources (Marek et al. 2015).

Analytical method needs solvents, reagents, energy, and it creates waste. The principles of green analytical chemistry in design of new methods includes prevention of waste (Principle 1); safer solvents and auxiliaries (Principle 5); design for energy efficiency (Principle 6); avoid chemical derivatives (Principle 8) and safer chemistry to minimize the potential of chemical accidents (Principle 12) (Agnieszka et al. 2013). Hence, the goal is to avoid or reduce the undesirable environmental side effects of chemical analysis, while preserving the classic analytical parameters of accuracy, sensitivity, selectivity, and precision.

4 Steroid Profile Analysis

The use of performance enhancing drugs in sports is prohibited by World Anti-Doping Agency (WADA) (WADA Prohibited List 2017). Various analytical strategies have been used to detect doping agents in the urine samples of athletes (Claudia and Shane 2014). In cases of quantitation of endogenous compounds, it is a very challenging since the unknown amounts of endogenous analyte that already exist in the samples (Ahmadkhaniha et al. 2010). An interesting case of endogenous compound analysis is determination of steroid in different bio fluids. The isolation and quantification of endogenous steroids related to endocrine disorders has become an important field of investigation for clinical laboratories such as testosterone replacement therapy (TRT). High sensitivity and selectivity are mandatory in the analytical determination of steroids, which can be presented at very low concentrations in relatively small and complex biological samples (Regal et al. 2009), veterinary growth promoter investigation (Noppe et al. 2008), as well as for environmental studies (Peng et al. 2008), doping control (Hintikka et al. 2008; Kuuranne et al. 2003; Thevis and Schanzer 2005), Alzheimer disease (Wang 2008) and inherited human disease (Lacey et al. 2004).

The anabolic androgenic steroids (AAS) are a family of hormones that includes the natural male hormone testosterone (T), together with numerous closely related chemical derivatives (Kanayama et al. 2010). All AAS possess both anabolic (muscle-building) and androgenic (masculine) properties, and they affect a wide range of physiological systems. The changing trends in steroid abuse have only been preceded by the rapidly advancing analytical technologies that can cover a wider range of compounds and achieve lower limits of detection (Scarth et al. 2012).

The method of steroid profiling (T/E ratio) was introduced into routine doping control by Donike et al. (1993). The ratios of these steroids have been proven to be very stable (Donike et al. 1993). The administration of steroids such as T, its precursors are proven to alter one or more parameters of the urinary steroid profile (Kerkhof et al. 2000). The latest effective date for Endogenous Anabolic Androgenic Steroids (EAAS) WADA Technical Document (TD) is TDEAAS2016. The purpose of this TD is to harmonize the approaches to the measurement and reporting of EAAS in urine, including data in support of the steroidal module of the Athlete Biological Passport (ABP) or “steroid profile”. Steroid profiling is one of the most versatile and informative screening tools for the detection of steroid abuse in sports drug testing. The “steroid profile” in the WADA technical document is composed of Testosterone (T), epitestosterone (E), androsterone (A), etiocholanolone (Etio), 5alpha-androstane-3alpha, 17beta-diol (5αAdiol), 5beta-androstane-3alpha, 17beta-diol (5βAdiol) and the ratio of T to E (T/E). These are measured as free steroid content obtained from the free steroid fraction plus those released from the conjugated fraction following hydrolysis by glucuronidase enzymes. Other urinary steroids or ratios of steroid metabolites that could be useful in evaluating a steroid profile are A/T, A/Etio, 5αAdiol/5βAdiol and 5αAdiol/E) (WADA TDEAAS2016).

5 Microextraction Technique as Sample Preparation

Sample pre-treatment is an important step in any analysis. Prior to the analytical determination, the analytes are first isolated from the matrix and pre-concentrated. Also, it is often necessary to clean-up the sample from the complex matrices. Classical sample pre-treatment techniques [e.g., liquid-liquid extraction (LLE) and solid-phase extraction (SPE)] are slow, labour intensive (Gyorgy and Karoly 2004) and consume large amounts of organic solvents. Additionally, in LLE, evaporation is an inevitable step in obtaining significant pre-concentration. Thus, this technique is both expensive and environmentally unfriendly (Kozlowska et al. 2003). In this context, SPE seems to be better, as smaller amounts of organic solvents are usually used. However, SPE cartridges are used only once; not only are these expensive but they also generate a great deal of waste. After use, SPE cartridges are sent to dumping grounds or, in certain cases, waste incineration plants. These practices are not environmentally-friendly (Agnieska and Tomasz 2011). In this case, microextraction techniques may offer a better option.

Microextraction techniques are generally defined as non-exhaustive sample preparation methods that utilise a very small volume of the extracting phase (μL) relative to the sample volume (Torres Padrón et al. 2014). Of these, the solid-phase microextraction (SPME), introduced by Arthur and Pawliszyn in 1990, have found their place in modern analytical laboratories while others such as the single-drop microextraction (SDME) (Jeannot and Cantwell 1996) and hollow-fibre liquid-phase microextraction (HF-LPME) (Pedersen and Ramussen 2008) have yet to become mainstream techniques. In 2006, the dispersive liquid-liquid microextraction (DLLME) was introduced. DLLME is a modified solvent extraction method and its acceptor-to-donor phase ratio is greatly reduced compared with other methods. In DLLME, the appropriate mixture of the extraction and disperser solvents is rapidly injected by syringe into aqueous samples containing analytes. Thereby, a cloudy solution forms. In fact, the cloudy state results from the formation of fine droplets of the extraction solvent which disperse in the sample solution. Then, this cloudy solution is centrifuged and the fine droplets become sediment at the bottom of the conical test tube. The determination of analytes in the sedimented phase can be performed by instrumental analysis (Rezaee et al. 2010). The DLLME technique, apart from its green features, is appealing as it uses common glassware and chemicals. However, the use of dispersive solvents may decrease the partitioning and the mass transfer of the analytes into the extraction solvent, thereby reducing the enrichment efficiency (Xue et al. 2014). The use of high density and toxic organic solvents (e.g., carbon tetrachloride, chloroform, dichloromethane, etc.) are other disadvantages of this technique (Leng et al. 2012). Further refinement of the DLLME technique gives rise to vortex-assisted liquid liquid microextraction (VALLME) and manages to overcome the drawbacks of the DLLME technique (Yiantzi et al. 2010). Yiantzi et al. (2010) introduced a new microextraction method termed VALLME, whereby dispersion of low density extraction solvent into water is obtained through vortex mixing, a mild emulsification procedure. The fine droplets can rapidly extract target analytes from water because of the shorter diffusion distance and larger interfacial area. After centrifugation, the floating extractant phase restores its initial single-drop shape for the following instrumental analysis. The VALLME technique, in which the dispersion of the extraction solvent is enhanced by vortex mixing instead of ultrasound irradiation, was devised (Yiantzi et al. 2010). VALLME overcomes the complexity of DLLME, where by the necessity of using a disperser solvent and the problem of possible analyte degradation resulting from the high temperatures and pressures, as well as the free radicals that are generated when using ultrasound; using a vortex for mixing is more cost-effective than an ultrasonic bath and a great deal less expensive than using an ultrasonic probe, and the dispersion formed under vortex-mixing is thermodynamically unstable, which means the extraction phase that contains the target analyte can be easily separated (Papadopoulou et al. 2011). Thus the major aim of this study is to discuss a simple and rapid sample preparation technique using VALLME in determination of 'steroid profile' in urine samples using Liquid Chromatography tandem mass spectrometry (LC-MS/MS).

6 LC-MS/MS Technique as Instrument Analysis

LC-MS/MS is a powerful analytical technique that combines the separating power of liquid chromatography with the highly sensitive and selective mass analysis capability of triple quadrupole mass spectrometry. A sample solution containing analytes of interest are pumped through a stationary phase (LC column) by a mobile phase flowing through at high pressure. Chemical interaction between the components of the sample, the stationary phase and the mobile phase affects different migration rates through the LC column affecting a separation. The wide variety of stationary phase and mobile phase combinations allow for customizing a separation to suit many complex solutions.

After elution from the LC column, the effluent is directed to the mass spectrometer. The mass spectrometer for an LC-MS/MS system has an ionization source where the LC column effluent is nebulized, desolvated and ionized creating charged particles. These charged particles then migrate under high vacuum through a series of mass analyzers (quadrupole) by applying electromagnetic fields. A specific mass/charge precursor ion (or parent ion) is targeted to pass through the first quadrupole, excluding all other mass/charge ratio particles. In the collision cell, the selected mass/charge ions are then fragmented into product ions (or daughter ions) by collision with an inert gas. The third quadrupole is used to target specific product ion fragments. The resulting isolated product ions are then quantified with an electron multiplier. This transition of ions from the precursor to product ion (also referred to as MS^2) is highly specific to the structure of the compound of interest and therefore provides a high degree of selectivity. The strength of this technique lies in the separation power of LC for a wide range of compounds combined with the capability of the MS to quantify compounds with a high degree of sensitivity and selectivity based on the unique mass/charge (m/z) transitions of each compound of interest.

Green chemistry which was introduced in the 1990s, aimed to minimise the environmental impact of diverse chemical activities, including those used in research (Shaaban and Gorecki 2015; Farré et al. 2010). In this scenario, green analytical chemistry plays an important role, e.g., by reducing hazardous wastes, using reusable materials, and/or employing eco-friendly solvents or green solvents. The last two terms refer to solvents that have a lower environmental impact resulting from their production, use, and disposal (life cycle assessment), and/or that allow health and safety impacts to be minimized (Pena-Pereira et al. 2015). The main goals of green analytical chemistry include the multi-analyte determination and the development of new (or modification of) analytical methodologies through the replacement of toxic reagents by smaller amounts of safer reagents, preferentially obtained from renewable sources (Gałuszka et al. 2013; Pena-Pereira et al. 2015). Several strategies have been used in LC–MS/MS, such as the reduction of the internal diameter and particle size (sub-2 μm) of chromatographic columns (to diminish eluent consumption), and the replacement of conventional mobile phases (consisting of acetonitrile and/or methanol) by environmental friendly alternatives like water, ethanol, and carbon dioxide in the particular case of supercritical fluid chromatography (Shaaban and Gorecki 2015; Shaaban 2016).

The use of smaller internal diameter and particle size (sub-2 μm) of chromatographic columns has contributed to it economic and environmental advantages (Joseph et al. 2014). As the column diameter decreases, so does the volume of mobile phase, which can lead to a considerable decrease in operational costs, especially when expensive mobile phase components are used such ultrapure modifiers or chiral additives. Likewise, reduced volumes of mobile phase obviously also are less of an environmental burden. As an example, a conventional 4.6-mm column typically operates at a flow-rate of 1 mL/min and will require about 1.5 L of solvent a day, a large percentage of which is an organic modifier (Joseph et al. 2014). A micro-LC system refers to LC using columns whose inner diameter is $\leq$0.5 mm, commonly 0.3 mm or using a 75 μm column only requires 25 mL of solvent per day. Depending on the percentage and type of modifier, this can represent a large cost saving on a yearly basis.

In this study, chromatographic analysis was performed with Thermo Scientific TSQ Quantum Access MAX equipped with Accela autosampler and Accela 1250 Liquid-chromatography pump and Xcalibur software (version 2.1) for data processing and analysis. Acetonitrile and formic acid (0.1%) (Mobile phase A) and water and formic acid (0.1%) (Mobile phase B) was used as the mobile phase in the experiment. The analytes (10 μL) were separated using Hypersil Gold column (50 $\times$ 2.1 mm, 1.9 μm) from Thermo Fisher Scientific with gradient programs and column flow rate was set at 200 μl min^{-1}. No derivatising agent was used in LC-MS/MS analysis. The 50 mm column resulted in total running time for LC-MS/MS at 10 min including equilibrium time, which is optimal for steroid profile analysis.

7 VALLME as a Sample Preparation Technique

Extraction was performed as shown in Fig. 2 (i) Urine sample (5 mL) which was added with endogenous steroid and deuterated internal standards was placed in a round bottom glass tube (10 mL). (ii) A 0.5 mL of *E. coli* in phosphate buffer (pH 6.4) was added into each tube and mixed. (iii) The mixture was then placed in the ultrasonic bath for 30 min at 50 °C for hydrolysis and then allowed to cool down to room temperature. (iv) Each extracting solvent (150 μL) (1-hexanol, 1-heptanol, 1-pentanol, 1-octanol, pentane, hexane, octane and tridecane) was added to the mixture and vortexed mixed at high speed. (v) The mixture was next centrifuged.

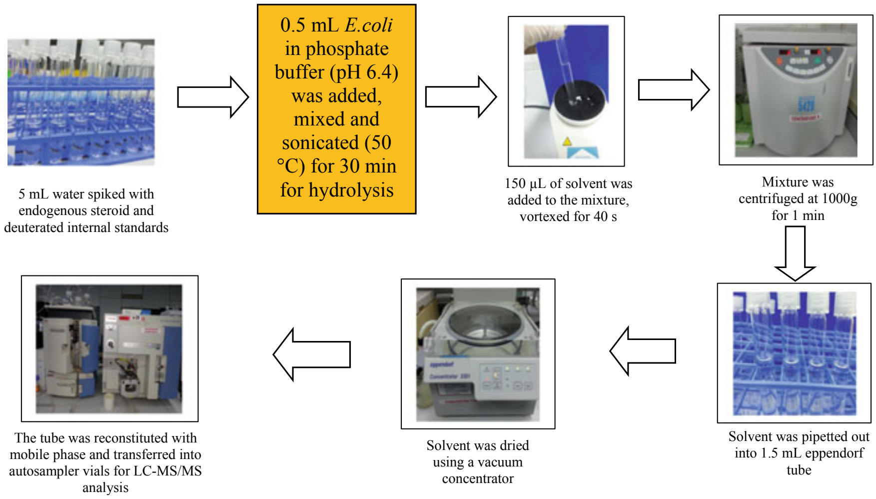

Fig. 2 Schematic diagram of the VALLME procedure

(vi) After phase separation, the solvent (top layer) was pipetted out into eppendorf tube (1.5 mL) and further dried using a vacuum concentrator. (vii) The tube was then reconstituted with mobile phase and vortexed. Finally the extracts were transferred into autosampler vials and analysed by LC-MS/MS (Fig. 2).

A suitable extraction solvent in every analysis should have the following properties: (i) low toxicity, (ii) immiscibility with water, and (iii) high extraction efficiency for the target analytes. In the VALLME process, a fine liquid–liquid dispersion system is formed. Thus, a good VALLME solvent must facilitate the formation of the micro droplets using vortex mixing and, after centrifugation, restore them as a single microdrop. Taking these requirements into account, a solvent with density lower than water, limited solubility in water and good formation of emulsion after vortexing were considered (Jia et al. 2010). High density organic solvents (e.g., chloroform, dichloromethane) were avoided due to their high toxicity. Organic solvents such as diethyl ether and terbutyl methyl ether which were previously reported (Cawley et al. 2009) for steroid extraction were also tested. However, the use of small amounts of these solvents formed a miscible layer with water due to their solubility in water (713 kg m^{-3} g and 740 kg m^{-3} for diethyl ether and terbutyl methyl ether, respectively). Eight organic solvents, categorized into two groups based on their solubility with steroid were investigated. Alcohol group solvents tested were 1-pentanol, 1-hexanol, 1-heptanol and 1-octanol while the alkane group solvents were pentane, hexane, octane and tridecane. A VALLME is dispersion of low density extraction solvent into water is obtained through using vortex mixing, a mild emulsification procedure. The fine droplets can rapidly extract target analytes from water because of the shorter diffusion distance and larger interfacial area. After centrifugation,

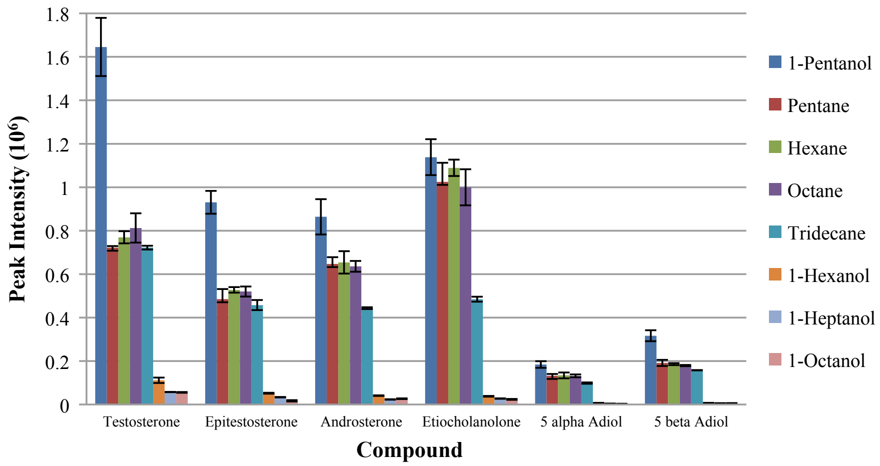

Fig. 3 Selection of different organic solvent on optimising VALLME. Conditions: sample volume, 5 mL; solvent volume, 150 μL, vortex time, 40 s, centrifuge speed and time, 1000 g for 1 min and no salt addition needed for the extraction

the floating extractant phase restores its initial single-drop shape for the following instrumental analysis.

The alcohol group solvents were considered because of their good solubility of hydroxyl steroids (Qiang et al. 2005). Usually in routine analysis, this endogenous steroid will be extracted using ter-butyl methyl ether (TBME) or diethyl ether but when small amount of these solvents are used, they form a miscible layer with water due to their solubility in water. Methanol is a good solvent for steroid but methanol, ethanol, propanol and butanol are miscible with water. So the longer carbon chain solvents such as 1-pentanol, 1-hexanol, 1-heptanol and 1-octanol are suggested. It is clear that 1-pentanol is the best extraction solvent compared to the other solvents (Fig. 3). So 1-pentanol was chosen for the rest of the studies.

A few other parameters have been optimised and validated as shown in Table 1. The adopted extraction conditions for 5 mL sample were: extraction solvent, 1-pentanol; volume of extractant, 150 μL; vortex time, 40 s; centrifuge speed and time, 1000 g for 1 min and no salt addition needed for the extraction (Table 1). The VALLME method is rapid (approximately 20 min) as compared to the standard method based on SPE and LLE (more than 2 h), excluding hydrolysis time.

8 Conclusion

This study present an interesting approach using VALLME as sample preparation followed by LC-MS/MS analysis for the simultaneous determination of endogenous steroid profile in urine. The method is rapid, simple and robust and is for the first

Table 1 The parameter, value and range of parameter used in optimising VALLME method and final adopted condition used in VALLME method

Parameter optimised	Value/range	Adopted condition
Extracting solvent	1-pentanol, 1-hexanol, 1-heptanol and 1-octanol, pentane, hexane, octane and tridecane	1-pentanol
Volume of sample	1, 2, 3, 4, 5 and 7 mL	5 mL
Volume of extractant	100, 150, 200, 300, 400 and 500 μL	150 μL
Vortexing time	10, 20, 30, 40, 50 and 60 s	40 s
Centrifuge speed	500, 1000, 1500, 2000 and 2300 g	1000 g
Centrifuge time	1, 2, 3, 4 and 5 min	1 min
Aliquoted volume	10, 20, 30, 40, 50 and 100 μL	100 μL
Salt effect (NaCl)	0, 5, 10, 20 and 30%	0%

time used for the determination of steroid profile in urine. A major advantage of the VALLME LC-MS/MS method is that it is rapid (less than 30 min) as compared to 4–6 h of the conventional method (SPE, LLE and GC-MS) (excluding hydrolysis time). The volume of solvent used is much less (150 μL). Satisfactory linearity ($r^2 > 0.990$), LOD (0.1 ng mL^{-1}), LOQ (0.5 ng mL^{-1}), repeatability and recovery (<10%) were obtained. In short, the proposed method fulfils the World Anti-Doping Agency (WADA) cut-off requirements, thus offering interesting options for steroid profile analysis of athletes.

From a scientific point of view, the usefulness of reducing LC column diameter for routine bioanalysis largely depends on the sample (injection) volume available. If there is sufficient sample, no significant gain in sensitivity will be obtained by the use of micro- or nano-bore LC–MS. On the other hand, when the sample volume is limited, injection onto a conventional column may lead to undesirable chromatographic dilution and miniaturization can be an attractive alternative that should be explored in case sensitivity needs to be improved. From a practical point of view, miniaturization will lead to less waste to dispose and to a reduction of solvent costs. Even though commercially available micro-LC systems have improved considerably over the last decade in terms of robustness, the importance of eliminating dead volumes and the associated risks in case of failure are still high compared with conventional LC systems. Additional advantages of the method are (i) low detection limits; (ii) short run time and (iii) low volume of eluent employed for each analysis. The study reported in this research showed the adopted microextraction method fulfilled all the features of analytical green chemistry with result are comparable and consistent with the conventional extraction and analysis (GC-MS) technique (Table 2). Furthermore, this technique supported Goal 13 Climate Action in SDGs by improving the extraction method with low volume of solvent and shorter analysis time in analytical chemistry to mitigate climate change and its impacts.

Table 2 Summary of green features of the developed method

Feature of green analytical method	VALLME
Prevention of waste	Small volume (150 μL) of extraction solvent Shorter hydrolysis time (30 min) Shorter column, small particle size
Safer solvent and auxiliaries	1-pentanol
Design for energy efficiency	Shorter analysis time
	Cost effective
Avoid chemical derivatives	No derivatisation for LC-MS/MS
Safer chemicals for accident prevention	Small volume

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A Survey of Laboratory Practice on Water Scarcity: Conservation of Drained Water from the Water Distillation Process

Siok-Yee Chan, Theam Foo Ng and Mohd Sayuti Hassan

Abstract Water recycling is a critical element that supports sustainable development. While the supply of fresh water is limited, both the world's population and demand for the resource continues to expand rapidly. According to Global Water, Sanitation, and Hygiene (WASH), approximately 2000 children are dying every day as a result of diarrheal diseases due to unsafe drinking water, inadequate availability of water for hygiene, and lack of access to sanitation. On the other hand, distilled water is highly needed due to the demands of wet research laboratories. The distillation process which concurrently generates distilled water and "waste water to drain" is often overlooked for its impact and potential. The massive amounts of drained water as a result of the distillation process in wet laboratories has motivated us to perform this study. Our study includes investigating the amount of water produced due to the water distillation process in a wet laboratory in Universiti Sains Malaysia (USM), Penang. The objectives of this study are to understand the factors contributing to water wastage among distiller users in USM and create awareness about the potential of water recycling from the water distillation process. This study is divided into two parts: the determination of the amount of drained water from the distillation process and survey about water conservation from the distillation process. Validated questionnaires are disseminated to USM residents, particularly to explore user practices and concepts about water conservation from the distillation process. This study found that the water used in producing distilled water is 74065.68 L per day and 2221970.40 L per month, which is equivalent to the basic need of 9875 individuals (according to individual needs stated by WHO). In addition, this study highlighted the overlooked wastage of tremendous amounts of drained water from the distillation process in the laboratory. Efforts and changes shall be imposed to avoid the contribution of the water distillation process to water scarcity. These efforts will support

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the concepts of Green Lab and also Sustainable Development Goals (SDGs) 2030 Agenda.

Keywords Water distillation · Sustainable development · Green lab · Awareness

1 Introduction

Water is an essential element in life. A minimum 2 L of water per day is required for hydration for an adult under ordinary conditions. Water consumption is estimated to be increasing in response to the increase in world population (Howard and Bartram 2003). Over time, this will lead to aggressive competition for clean supply of drinking, bathing and cooking water. According to National Geographic, while 70% of the world's mass is water, only 2.5% of this is freshwater which can be consumed while the rest of it is saline and ocean-based. From the 2.5% of freshwater, only 1% of it is easily accessible and the remainder is trapped in glaciers and snowfields. Hence, only 0.007% of water is accessible to the current world population, i.e., 7.6 billion people (Zachos 2017; Tran et al. 2016). According to United Nations, by 2025, 1.800 billion people will be living in areas or countries with water scarcity problems and 1.6 billion people will be facing lack of necessary infrastructure for access to river water and aquifers (Food and Agriculture Organization of the United Nations 2016). Clean water, basic toilets and good hygiene practices are essential for the survival and development of children. Today, there are around 2.4 billion people who do not use improved sanitation, and 663 million who do not have access to improved water sources. For children under five, water and sanitation related diseases are one of the leading causes of death. Every day, over 800 children die from preventable diseases caused by poor water quality, and a lack of sanitation and hygiene (UNICEF WASH 2017; UNICEF 2017).

Water has also become an essential resource for development in many developing countries. There has been heavy weightage on use of water in construction, agriculture, infrastructure as well as research (Food and Agriculture Organization of the United Nations 2016; Wang et al. 2011). Particularly in science research labs, water is used in the form of distilled water which is prepared from tap water that is generally regarded as clean water for daily use. From the tap, water is piped through the distiller for boiling and the evaporated steam is cooled down to condense it into a clean collector for further use. In the process, the non-distilled water will flow through the outlet and be drained off via sink. The used of distilled water is to ensure accurate judgment of the effect of water and moisture to the subject of interest. This is to avoid the effect of mineral build up that may affect the studied subject. The collected water is clear from minerals, chemical and impurities, and has no elemental traces in it, i.e., clean water with purity level of 99–99.9% (Kozisek 2005; Hulett 1896). Frequently, research institutions will invest in purchase of a water distiller in order to act as an in-house distilled water source. Despite the different range of water distillers, the main principle of distilling water is the same. Water input from the tap and output of the non-distilled water was always drained instead of reused. The sources of clean sanitized water resources (from the tap) are being degraded and diminished when it is drained down as waste. The possible amount of water drained in this case had previously been disclosed in only one journal back in 2004 (Sharma 2004, 2011).

Ironically, as the issue of global warming is becoming more alarming to humankind, researchers are searching for sources of water via desalination of groundwater aquifers (Zachos 2017) instead of considering the drained water from the distillation process as alternatives to recycled water for non-potable usage. Human awareness on the amount of waste water drained from water distillation may be the cause of ignorant. In recent years, sustainable development goals (SDGs) have been widely introduced around the globe. This sustainability idea initiated since 1970s with the Rio Declaration trigger in June 1992. Among the 17 sustainable development goals (SDGs), Goal #6 stated "ensure availability and sustainable management of water and sanitation for all". It emphasized the importance of water management in sustaining humankind. Following this, the Green Lab concept was recently introduced aiming to save energy, reduce waste, conserve resources and others (Durrant 2017). However, despite the frequent glimpse of the word "sustainability", this idea is still lacking in the people of a developing country like Malaysia, which leads to inefficient use of the current resources. This phenomenon is vividly witnessed with the distillation process in many research labs.

Onto study the effect of water distillation and the potential of saving water resources from this process, this paper explores the laboratory practice on water scarcity in relation to waste water management from the distillation process. Here, we carry out an extra step to study the perception of locals on water wastage from the distillation process as well as the future behavioral trend of the respondents in a local university toward the water conservation issue.

2 Methodologies

The discharged water which is coming from an outlet of a water distiller can be regarded as clear from dangerous organisms since it has been boiled. Even though it may contain a relatively higher concentration of minerals it is clean. The fact that this discharged water is being drained to the sink is considered a waste. The amount of water drained daily appears to have been deemed to be negligible since most research have not recognized its effect on water consumption. In order to alert the researchers and re-introduce water conservation from the distillation process, experimental work has been carried out as follows.

2.1 Amount of Water Used in the Distillation Process

The flow of water was recorded by measuring the amount of water collected in a defined time frame. Four different flow rates were taken as investigation parameters. After determining the flow rate, the tap was connected to a water distiller and the distillation process was commenced. The discharged/waste water was collected from the outlet of the distiller and the volume generated was measured when 50 mL of distilled water was collected as yield. At the same time, the temperature of the water collected from the distiller outlet was also recorded. Data is presented as different flow rate versus amount of waste water and distilled water generated.

2.2 Amount of Water Used in the Laboratory

The number of water distillers were recorded in each School in USM which has a wet laboratory. The time of which the distiller is set/switched to "ON" was also confirmed from each lab. The total amount of water generated from the distillation process in a day in USM was then calculated.

2.3 Structured Questionnaires

In addition to experimental work, the validated questionnaires that are related to the water conservation issue were disseminated to USM communities/residents. The validated questionnaires are comprised of open and closed questions and designed using the Google Form. The target respondents were lab users who are researchers, postgraduate students, undergraduate students and lecturers from the various Schools of Sciences in USM. The survey items (as shown in Table 1) included socio-economic information, knowledge, perception and practice on the topic of water conservation.

2.4 Respondents and Data Collections

This research has been reviewed and approved by *Undergraduate Human Ethic Committee* for research involving human subjects. Respondents were invited to fill in the survey form through USM administrative email addresses. The participation was completely voluntary. All data obtained was devoid of name, email address or IP address and it was stored in a password protected electronic format in order to protect confidentiality.

Table 1 Survey Items

1.	Do you know that to generate 100 mL of distilled water we need 4000 mL of tap water? Yes/No
2.	Based on question 1, do you think that it is a waste of resource? Yes/No
3.	Are you aware of water conservation issue? Yes/No
4.	Have you thought of the other potential uses of the non-distilled water? Yes/No
5.	How long the distiller in your lab does is switched ON during a working day? Selection
6.	In your lab, does the non-distilled water being collected from the distiller during the distillation process? Yes/No
7.	Do you think that USM should apply green lab concept in designing new lab?
8.	Will you support the use of non-distilled water from distillation processes?
9.	I am willing to use the non-distilled water from the distiller after water distillation process. Likert scale
10.	I am willing to get involved in water conservation program. Likert scale

2.5 Statistical Data Analysis

Data collected through questionnaires was analyzed using SPSS. The data was analyzed using Pearson correlation test, and *P*-value of less than 0.05 was taken as significant level.

3 Result and Discussion

3.1 Laboratory Experiment

Four different tap water flow rates compatible with the distiller are identified, i.e., one low rate, two medium rates and one fast rate. It is found that the flow of tap water is not linearly correlated to the amount of waste water drained to the sink. As expected, higher amount of water is wasted if one uses higher rate of tap water flow through the distillation machine when preparing distilled water for lab use. Figure 1 shows the plot of amount of water drained from the outlet of the distiller against water flow rate.

When the amount of drained water was compared to the generated distilled water, it is noticed that a low percentage of distilled water was generated in fast flowing tap water, i.e., approximately 1.8% from the water consumed (Fig. 2). On the other hand, the amount of distilled water generated in a slow and medium flow rate of water revealed almost identical production efficiency, i.e., 4.9 and 4.8% for flow rate of circa 10 and 20 mL per second, respectively. This indicated that, faster tap water flow rate reduces the efficiency of the distillation processes. Optimally, it is suggested

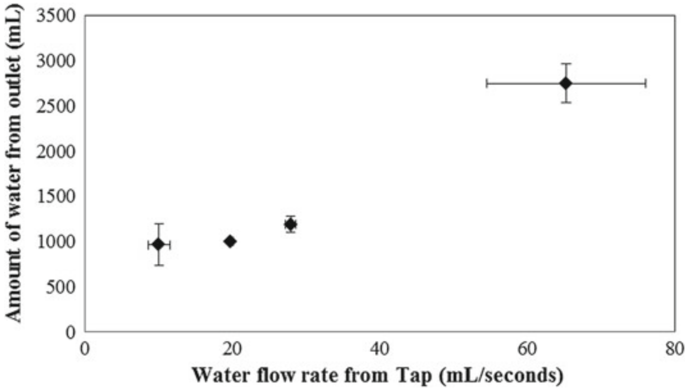

Fig. 1 Amount of waste water generated from a laboratory scale distiller machine using different rate of water flow (n = 3)

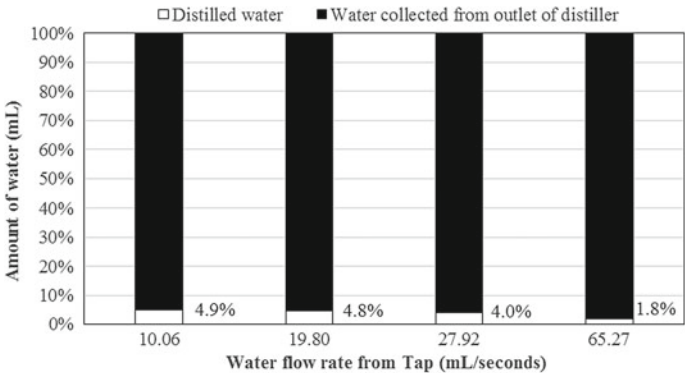

Fig. 2 Distillation efficiency: ratio of distilled and drained water generated from a lab scale distillation process in percentage

that, a medium flow rate of tap water be used to pipe through the distiller in order to achieve cost effectiveness of the process.

3.2 Amount of Water Drained as Waste from Distillation Process

To identify the total amount of water consumption in the distillation process for a research university like USM, five School of Sciences which have been identified as heavy users of distilled water were involved in the survey. The total number of water distillers in the main campus of USM is 81. The average time operated for the water distillers in the respective schools was summarized from the survey form conducted

Table 2 Water consumption by distillation process in research labs of five schools of sciences in USM per month

School	Hours per working day	No. Distiller	Water drained (L)
Physics	6	2	65033.28
Pharmaceutical sciences	6	22	715366.08
Industrial technology	6	15	487749.60
Biological sciences	4	18	390199.68
Chemical sciences	4	23	498588.48
Institute for research in molecular medicine	6	2	65033.28
Physics	6	2	65033.28
Total	32	82	2,221,970.40 (586982.48 gallons)

from the respondents. The obtained time was used to approximate the total amount of waste water generated from the water distiller per month that has been drained. Table 2 displays the number of distillers, time of their operation and amount of water approximately drained from the distiller per month in these five schools in USM.

According to Table 2, the majority of the Schools of Sciences turn their distiller "ON" for about six hours during a working day. As a result, approximately 88 thousand gallons of water were drained from laboratories in USM per month. This amount has contributed to approximately 4% of the water bill of USM.

Malaysia is a rainforest country. This has blessed us with a relatively low water bill (Abidin 2016; Free Malaysia Today 2017). The scenario is different in other countries where water is a precious element and needs to be used cautiously. Hence the amount of water, i.e., around 587 thousand gallons drained in USM may be critical for a water poor country such as India or area such as Africa. Table 3 presents the worth of the drained water if it is converted to the water tariff in other countries (Team Poly 2016; Every Little drop story 2010; Singapore's National Water Agency 2017).

3.3 Survey Responses

A structured survey was administered to USM residents to identify the perception of USM residents on the water conservation issue, particularly in terms of recycling water from the water distillation processes. A total of 241 respondents participated in the survey. These respondents are lecturers, postgraduates and undergraduate students as well as lab assistants. Table 4 shows the sociodemographic factors of the respondents.

Table 3 Equivalent water bills per month when the amount of drained water from distillation process found in Table 2 was converted to water tariff in other countries

Countries	Water tariff	Dollars/monthly	RM[a]/monthly
Penang	RM 0.32 (Free Malaysia Today 2017)	–	711.03
Sweden	$0.58 (Every Little drop story 2010)	1288.74	2603.26
Canada	$0.40 (Every Little drop story 2010)	888.79	2817.46
South Africa	$0.47 (Every Little drop story 2010)	1044.33	3195.64
USA	$0.51 (Every Little drop story 2010)	1133.20	4419.50
Spain	$0.57 (Every Little drop story 2010)	1266.52	6142.64
Ireland	$0.63 (Every Little drop story 2010)	1399.84	6789.23
Finland	$0.69 (Every Little drop story 2010)	1533.16	7435.82
Singapore	$1.17 (Singapore's National Water Agency 2017)	2599.71	7747.12
Italy	$0.76 (Every Little drop story 2010)	1688.70	8190.18
France	$1.23 (Every Little drop story 2010)	2733.02	1,1424.04
Netherlands	$1.25 (Every Little drop story 2010)	2777.46	13,470.70
UK and Northern Ireland	$1.18 (Every Little drop story 2010)	2621.93	14,499.25
Australia	$2.35 (Team Poly 2016)	5221.63	16,448.14
Belgium	$1.54 (Every Little drop story 2010)	3421.83	16,595.90
Denmark	$1.64 (Every Little drop story 2010)	3644.03	17,673.55
Germany	$1.91 (Every Little drop story 2010)	4243.96	20,583.22

[a]The currency conversion to Malaysian Ringgit (RM) is based on currency on 31 January 2018. Lowest water tariff was taken based on first one thousand meter cube. This is excluding any surcharge after usage of water reaches 35,000 L

Table 4 Sociodemographic of the respondents

Characteristics	Number of respondents (n = 241)	Percentage
Gender		
Male	163	68
Female	78	32
Nationality		
Malaysian	219	91
Foreigner	22	9
Age (in years)		
Less than 20 years	12	5.00
>20–25 years	112	46.50
>25–45 years	104	43.20
>45–60 years	11	4.60
>60 years	2	0.80
School		
Pharmaceutical sciences	87	36.10
Biological sciences	28	11.60
Chemical sciences	23	9.50
Industrial technology	19	8
Physics	20	8.3
others	64	26.6
Occupation		
Undergraduate student	113	46.90
Postgraduate student	61	25.30
Lecturer	38	15.80
Lab assistant	10	4.10
Others	19	7.90

3.4 Awareness on Water Conservation

Based on the given questionnaire to the respondents, we found that the majority (more than 70%) of respondents reacted positively to the idea of water conservation as shown in Fig. 3. The respondents declared that they are aware of water conservation issues. There are a minute amount of respondents, i.e., 1.2% who stated that they are not aware of water conservation. Awareness of the water conservation issue was not significantly correlated to respondents occupation ($p = 0.463 > 0.05$, r^2 0.048). This suggests that awareness of water conservation is seen across different groups of people.

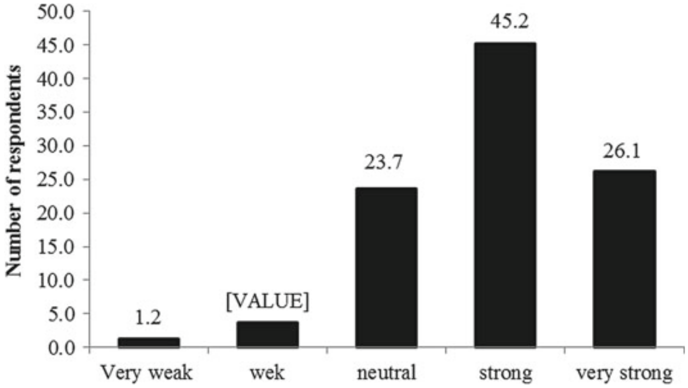

Fig. 3 Respondents awareness toward water conservation issue

Table 5 Pearson correlation test between awareness, perception and willingness of involvement

	Awareness	Perception	Involvement
Awareness		$r^2 = 0.344$ $P < 0.000$	$r^2 = 0.330$ $P < 0.000$
Perception	$r^2 = 0.344$ $P < 0.000$		$r^2 = 0.373$ $P < 0.000$
Involvement	$r^2 = 0.330$ $P < 0.000$	$r^2 = 0.373$ $P < 0.00$	

Table 5 presents the Pearson correlation test between the 3 components tested, i.e., awareness, perception, and involvement. It was found that all the components were significantly correlated to each other with the P value less than 0.05. The awareness of water crisis and conservation issue has shaped the perception of water usage and management which eventually influenced the physical involvement of people in conservation activities. Here, it is suggested that awareness is important in leading to the right perception and willingness of USM residents in involvement in water conservation programs.

3.5 Awareness and Practice Among the Lab User

As the water distillation process is a common process in laboratories, the responses from lab users are critical in assessing the water conservation practice in their respective labs. Among the total of 241 respondents, 169 (73.2%) of them are lab users (Table 6). Among these respondents 81.87% declared that they practiced water conservation in their daily life. Despite knowing the detail of the distillation process as well as the different between the distilled and non-distilled water, the majority of the lab users (approximately 75%) didn't have the knowledge about the amount of

Table 6 Responses of the lab user

Description	Yes	No
Practice in daily life?	140 (81.87)	31 (18.13)
Knowing the process	163 (95.32)	8 (4.68)
Know the different	164 (95.91)	7 (4.09)
100 mL need 4 L water	43 (25.15)	128 (74.85)
Do you think is a waste?	149 (87.13)	22 (12.87)
Collected for general washing and plant watering	36 (21.30)	133(78.70)

water consumption from the distillation process. Since there is a lack of awareness of the water wasting issue from a distillation process, there is only a low percentage of them (21.30%) that used the non-distilled/waste water for other purposes. In spite of this, 87.13% of them regarded the drained water from the distillation process as a waste of resources.

Further scrutinizing the lab user's practice, it is found that a lot of respondents didn't recycle the non-distilled water during the process of producing distilled water (approximately 79%). Only some labs in the School of Pharmaceutical Sciences and the School of Biological Sciences had recycled the non-distilled/waste water for general washing of apparatus.

3.6 Willingness on Water Conservation from Distillation Processes

As mentioned in the previous paragraph, the majority of the respondents agreed that the distillation process that drained the outlet water is a waste of resources. Having agreed to the idea, the willingness of the respondents to reuse the non-distilled water from the distillation process was found to be significant ($P = 0.004, <0.05$). However, to our surprise the awareness of the waste of water resources from distillation doesn't correlate significantly to the willingness of involvement in the water conservation program ($p = 0.234$, >0.05, r^2 0.77). This is in contrast to the observation of the relationship between general water conservation issue (Q1) and direct involvement of activities (Q10). This indicates that there might be other underlying factors affecting the view point of recycling the non-distilled water for humankind.

3.7 Suggestion on Potential Use of Non-distilled Water from Outlet of Distillation

A total of 84.7% of respondent support the recycling of non-distilled water from the distillation outlet and 14.9% remain neutral. One person responded negatively and disagreed with the recycling of the drained water. Out of the 84.7% who have agreed on recycling the drained water, the majority suggest the potential use for general washing. In response to open ended comment, some respondents have suggested the potential use for car cleaning, gardening, and as a water reservoir for emergency use. Only one respondent suggested to reprocess the non-distilled water as a drinkable source of water.

4 Discussion

Water is essential daily life. In developing countries, water in research activities is also essential in ensuring their development. On the one hand, research activities are expected to assist with worldly development and progression, ironically, on the other hand a tremendous amount of water was witnessed being drained down the sink. Quality of the drained water was degraded and diminished instantly just because of improper management of the water waste from the distillation processes. According to the United Nations World Water Development Report 3, water resources management is directly linked to global crises. This could affect climate change, food supplies, prices, energy and sanitation (Tran et al. 2016).

Poor sanitation in some countries is reported to cause 280,000 diarrheal deaths annually due to disease transmission such as cholera, diarrhoea, dysentery, hepatitis A, typhoid and polio (UNICEF 2017). The WHO fact sheet updated in July 2017 stated that, 842,000 people died as a result of inadequate water, sanitation and hygiene annually. This number is equivalent to 2305 people dying per day due to poor sanitation. Taking the basic requirement of 7.5 L water needed per person per day suggested by WHO (WHO 2017), the amount of water drained from the water distillation process by research institutions in USM is equivalent to the amount of water required to support 9628 people in a day. This amount is more than enough to save the lives of people from dying (to recap, 2305 people died per day) due to poor sanitation. Based on the United Nations suggestion, a person shall only use 165 L per person per day. This means that the drained water recorded from the current study could supply up to 434 heads per day in normal daily household usage. This number is almost equivalent to the supply of a whole block of an apartment with typical 14 floors of 8 unit per level occupied by 4 tenants.

Malaysia has been blessed by water resources. Every year, Malaysia receives 3000 mm^3 of rain fall which supplies 900 billion m^3 water resources (Abidin 2016). Malaysians utilize water resources averaging 300 L in daily life which is twice the benchmark mentioned by the United Nations. In Penang itself, water consumption hovered at 286 L per person per day in 2016. According to a report, the State Government of Penang had expressed regret on the issue of over used water in Penang (Free Malaysia Today 2017). The poor water management system is partly to be blamed for the high water consumption record in Penang. The high water consumption among the Penangites was due to its low water rates of only about 32 cents per meter cube for the first 35,000 L per consumer per month. In monetary terms, the water wastage drained from the distillation process constitutes about 4% of the total water bill in USM. When the amount of water is calculated based on local household tariffs, it worth circa RM 8532 yearly. This amount can hit up to RM 35,000 if s similar situation occurred in Johor, Malaysia (RM 1.32 per meter cubic). The wastage corresponds to approximately RM 90K ($30,416.55 with $1.17 per meter cubic) annually based on the water tariff of our neighboring country, Singapore (Singapore's National Water Agency 2017). More conversion have been done as presented in Table 3 and the numbers are worrying and may impact human life silently.

Originally, human perceptions and attitudes toward water resources is the key influence on the practice of water conservation (de Miranda Coelho et al. 2016). For instance, people that are not aware of water conservation issues are likely to increase the usage of water or waste the water. In the current study, responses from the participants is sheds light on the perception of water users towards conservation of water. They have positively responded to the initiative of raising the current problem in the view of water scarcity. Respondents' awareness of the water conservation issue is important as it shows significant correlation to the perception and willingness of involvement in water conservation programs ($p < 0.05$). However the majority of the respondents have revealed their ignorance of the tremendous amount of water consumption/wastage from the distillation process. When the respondents were asked about their support of water recycling from the distillation process, 15 respondents revealed doubt and did not support its reuse. Their reasons include the involvement of high cost in re-processing the water, and some even stated their despair on being unable to control the conservation idea and hence giving up. Most of the respondents expressed their willingness in supporting and being involved in the water conservation project. This indicated that the USM residents are ready to open their arms in embracing changes toward a more sustainable water management.

Distilled water is water that has had many of its impurities removed (Kozisek 2005; Hulett 1896). It is collected through the distillation process. Water that was not successfully distilled or vaporized as steam will be discharged through the outlet and drained into the sink. The "drained water" that is not collected during the distillation process consists of slightly concentrated water with pre-existing minerals or chemicals that are used to treat tap water. Based on the distilled and drained water ratio as shown in Fig. 2, it is approximately 5% more concentrated compared to normal tap water. As there may be concern regarding the impact of this impurity, water quality of the water produced shall be included as consideration when devising further use of this water (Kozisek 2005). According to the response from the current study, this recycled water was suggested to be used for non-potable purposes such as gardening, general cleaning, landscape and public parks. Other potential non-potable applications may include cooling water for power plants and oil refineries, industrial process water for such facilities as paper mills and carpet dyers, toilet flushing, dust control, construction activities, concrete mixing, and artificial lakes. Some have even suggested for the water to be recycled and further processed for potable use.

5 Conclusion

The fact that the amount of drained water from the water distillation process is tremendous exerts pressure to recycle it. The amount may seems trivial in monetary terms in the context of a blessed country like Malaysia, however this amount could impact significantly in country where water crisis is causing daily death. Besides, with the 587 thousand gallons of water, it could affect the life of flora and fauna in the area. The positive responses among USM residents are optimistic for appropriate action to be taken toward sustainable water management. It is suggested to use the resources for non-potable purposes such as general cleaning. This will not only conserve water resources but will also benefit the environment via providing a dependable, locally-controlled water supply. The quality of the collected water from the outlet can also be tailored to a specific water use that subsequently reduces the energy needed to treat water. For instance, water quality required for a secondary pipe to be used for flushing a toilet in Malaysia is less stringent than the water quality needed for drinking water. In addition, recycling the drained water can also decrease wastewater discharge and create or enhance wetlands. Future plan following the current observation is developing an affordable water distillation plan on site with minimal water discharge in solving the water wasting concern.

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Conflict of Interest Authors declared no conflict of interest.

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Sustainable Energy Model in Tecnocampus Higher Education Smart Campus

Virginia Espinosa-Duró, Julián Horrillo and Marian Buil

Abstract CO_2 emissions are one of the main causes of climate change and global warming. Countries should implement the UN Agenda 2030 and the Sustainable Development Goals, placing universities as part of the issue. This paper describes a sustainable energy model based on the promotion of the use of a local district heating and cooling (DHC) distribution system that uses renewable energy sources and the design and implementation of energy efficiency strategies to address climate requirements in one of the buildings of the Tecnocampus University Campus. In addition, a Living Lab approach to further enhance the model, has been also proposed. The ultimate goal will be to achieve a *Nearly Zero Energy Building* (nZEB) approach, understood as a building that has a very high-energy performance, in an effort to reduce emissions and meet the new ambitious EU regulatory demands. Final results presented show the reduction of the environmental impact of the University Campus. This paper will be useful for academics, policy makers and smart cities interested in developing sustainable initiatives on campus by using a sustainable energy model.

Keywords Climate change · Nearly zero energy buildings (nZEB) · District heating and cooling (DHC) · Energy efficiency · Living lab

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1 Introduction

Few issues have a greater impact on our lives and on the sustainability of the planet than the climate change. Launched in September 2015, the United Nations Sustainable Development Goals (SDGs) of the 2030 Agenda (United Nations 2015) are focused on 17 actions to end poverty, fight inequalities, protect natural resources and curb climate change by 2030, fully integrating the three dimensions of the sustainable development: economic, social and environmental one. Each goal define a set of specific targets to be achieved over the next 12 years, taking special attention on the 13 Goal ("*Take urgent action to combat climate change and its impacts*") as one of the greatest challenges of this century in order to preserve the Humanity and its environment how we have conceived it till now. According to fifth assessment report of the Intergovernmental Panel on Climate Change of the UN (IPCC 2014), reduction in CO_2 emissions becomes a key factor in order to reduce one of the main greenhouse gases due to its extremely long atmospheric lifetime and its direct contribution to the climate change effects.

In this context, Governments have been designing a package of regulatory and incentive measures in order to stablish a new green framework to face climate crisis. Thus, European Union has put forward climate action as the central driver by defining its EU 2020 Agenda (best known as the "20-20-20") and its 2030 Climate and Energy Framework (EU 2014). These European Union's 2020 headline targets include a set of measures for promoting renewable energy sources in the electricity, biofuels and heating and cooling sectors, and a second set of strategies aimed at improving the energy efficiency, specially, on the largest energy consumer sectors in the EU: transport and building sectors. As mentioned in report 483 final/2 of The Commission Parliament in 2013 (COM 2013), nearly 40% of final energy expenditure and 36% of greenhouse gases is caused by European buildings. In order to address this concern, EU is currently strengthen its efforts on promoting the improvement of the energy savings of both new and existing buildings within the Union, through the Directive on the Energy Performance of Buildings (EPBD 2010). This Directive introduces and highlights the concept called *Nearly Zero-Energy Buildings* or *nZEB*. In accordance with its Article 2, nZEB refers to a "*building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby*."

In a parallel effort, a large number of organizations and institutions have been managed a significant transition towards a green economy embracing a set of different sustainable strategies to operationalize such transition. In this regard, Higher Education Institutions (hereafter, HEIs) have acted as appropriate sites to address sustainable purposes over the last decade (UNESCO 2009; Casajeros et al. 2017). Along the same lines, Universities should also contribute to the achievement of the 2030 Agenda and the goals and targets it contains (GUNI 2017), thus becoming drivers of change towards sustainability. Nonetheless, as is widely discussed in the literature (François 2015; Grau 2015; GUNI 2017), only a paradigm shift in reframing the role of HEIs from both global and local “-or glocal-” perspective will be required to give a comprehensive answer to this approach.

The literature provides several strategies aimed at moving HEIs toward new campuses modelled on a glocal framework. The Living Lab approach first explored by W. J. Mitchell, K. Larson and A. Pentland at the Massachusetts Institute of Technology, has emerged as an attractive and useful methodology for addressing this transition. This approach aims to integrate users and actors for the co-creation of complex solutions in evolving real-life scenarios (von Geibler et al. 2014). Robinson et al. (2011) identifies that the campus understood as a living laboratory infrastructure is essentially an extension of the strong traditional university model. The critical difference between both models is that while in the standard model university activities (research, teaching, applied learning, outreach, and institutional management mainly) take place within areas with well-defined boundaries, this new approach proposes a review of the traditional role of interaction among departments and collaborative partnerships providing new forms of trans-disciplinary working to address problematic issues.

This paper focuses on describing the sustainable energy model of the Tecnocampus Higher Education Smart Campus, which undertakes the promotion of a local district heating and cooling from renewable sources of energy and the implementation of appropriate actions aimed at energy saving and improvement of energy efficiency while covering climate requirements. In this contribution, the proposed model is applied at one of the buildings of the HEI belonging to the Tecnocampus. The rest of the paper is organised as follows: Sect. 2 briefly introduces the Tecnocampus technology park and the proposed Living Lab approach for extending the performed sustainable energy system. Section 3 presents a detailed description of the Tub Verd clean energy provider and the strategies and activities aimed at a better energy performance. Section 4 shows outcomes and discussion and Sect. 5 and last, draws general conclusions and future lines.

2 Tecnocampus Living Lab

The Tecnocampus Mataró-Maresme Foundation (hereafter, Tecnocampus or TCM) is a Technology and Innovation Park, fully recognized as a member of the International Association of Science and Technology Parks (IASP). The mission of the TCM is to contribute towards the economic and sustainable development of the region, acting as a driving force behind the generation of knowledge, training, business and innovation, fully fulfilling the standards of most scientific and Business Parks stated in the literature (Zhang 2005; Lööf and Broström 2008; Yang et al. 2009). The TCM Park is composed by a Higher Education Institution affiliated to Pompeu Fabra University that integrates three faculties (polytechnic, economics and nursery studies) and a cluster of technological companies, creating the pursued dynamic environment of education, collaboration and innovation. The HEI has been designed and perceived not only as a member but also the nuclear part of the Tecnocampus, positioning ourselves strategically as key players in the Park. This design has offered us the opportunity of sharing our vision on the variety of new complex sustainable development challenges with the rest of our partners.

In this respect, a need to explore new forms of multidisciplinary and trans-partner interaction aimed at driving the whole Park movements toward sustainability, has been identified. On the other hand, and as already discussed at the previous section, a "glocal HEI" model is required when dealing with these issues. In response with these needs, a living lab approach as an accurate cooperation working tool for sustainable issues, has been proposed. This methodology has revealed itself to be appropriate in handling the transition that every stakeholder needs to undertake to overcome traditional model boundaries.

According to Grin et al. (2010) and going in depth to effectively fit sustainability into such an integrated trans-disciplinary oriented manner, three types of agency must exist: an agency to change structures, an agency to pursue novel practices, and an agency to link novel practices to structures. Building on this framework, the following agencies to promote the progressive construction of a space consisting of a multidisciplinary and networking approach, have been matched at the TCM smart campus:

i. *The Equipment and Infrastructures Department* of the TCM, identified as both agencies type #1 and #3.
ii. Our *GRESIT Research Group* (Alternative and Renewable Energies, Sustainability, Energy Efficiency and Industrial Technological Innovation Research Group), identified as an agency type #2.

Subsequently, a set of round tables between ourselves (tagged as agency #1) and the Equipment and Infrastructures Department (-tagged as agencies #1 and #3-), was launched for devising the necessary strategies and mapping energy issues on the campus. These identified agencies, takes advantage of both our technological and sustainability skills, and the decision capabilities and knowledge background of the Infrastructures Department in order to work together for improved energy issues decision making.

The role of the TCM Living Lab infrastructure (hereafter, TCM-LL) will be to further improve the capacity of the TCM to incorporate methods and tools for defining and co-creating new innovation processes towards a reduction in energy consumption. The aim of the first stage of the TCM-LL is to build a strong basis for knowledge sharing between the different identified agencies, while the ultimate goal of the proposal must be to guarantee the convergence towards the *Nearly Zero Energy Buildings* approach of all the buildings within the Technology Park.

In the following two sections, a detailed description and assessment of the technological decisions already planned and carried out by the Tecnocampus Park in an effort to reduce emissions and meet the new ambitious EU regulatory demands, may be found.

3 Technological Solution

According to Directive on the Energy Performance of Buildings (hereafter EPBD), the three following appropriate actions, shall be driven for the pursued energy savings characteristic of the *Nearly Zero Energy Buildings* (hereafter, nZEB):

a. Further promotion of the use of renewable energy.
b. Energy efficiency improvement in cooling, heating and electricity systems and in its cost.
c. Building envelope enhancement by improving its thermal insulation and solar protection.

The Technological solution purposed to ensure a reliable approach towards a nZEB performance, is broken down in two clearly different strategies for respectively covering the first two actions referred to above, which are central to all energy transitions (IEA 2017): The first one is focused on exploiting the power of the nearby *Tub Verd* affordable and energy provider system from renewable sources, configured as a heat and cold distribution piping network for satisfying TCM climate requirements. Energy efficiency improvement has been the other fundamental conducted strategy for the achievement of a better energy performance. Note that in this first stage of the global project, we have focused our analysis on one of the two University buildings of the Park, called TCM1. A detailed description of both main strategies is presented at the following subsections.

3.1 Tub Verd Technology

Mataró city has gained a well-deserved recognition for its role in promoting renewable energies. It is in fact known as an energy sustainable city. The Tub Verd (literally "Green Tube") project is an example. Tub Verd is an urban network configured as a district heating and cooling (hereafter, DHC) distribution system. A lot of discussion addressing District Heating (DH), District Cooling (DC) and DHC technologies and potential enhancements, exists in the literature (Rezaie and Rosen 2012; Li et al. 2017.). According to Werner (2017), the fundamental idea of district heating is to harvest heat resources or local fuel in order to support local end-user heating demands that would otherwise be wasted by employing an urban network of heat distribution. Likewise, DHC systems can be supplied by a combination of different energy sources. Traditional primary energy sources that perform as excess heat suppliers, are Waste-to-Energy (WtE) plants through waste incineration processes (Persson and Münster 2016), Cogeneration systems also known as Combined Heat and Power (CHP) plants (that simultaneously produce thermal and electric energy by using the same process) and Industrial Processes where the exhaust heat energy resulting from different high temperature processes is also recovered (Naegler et al. 2015). All these pointed processes represent an efficient alternative to conventional technologies due to their high EE performance.

District cooling operates on the same principles as district heating, whereby chilled water is produced centrally and distributed through a network of insulated pipes. This implies the benefit of removing the requirement for energy intensive local cooling in buildings, thereby extremely reducing its total carbon footprint, as previously mentioned. The cold supply is managed in different ways: by using natural sources of cooling, such as the sea or lakes (essentially in countries with cold weather), through processes that have cold as a by-product (a good example is the transfer of the recovered cold from the LNG re-gasification process in Barcelona port terminal of Mercabarna's refrigeration chambers through a DC system), and finally, and the same as in DH systems, by means of excess heat resources, such as industrial processes or WtE plants, in such case driven by absorption chillers often assisted by mechanical chillers. These methods, jointly with the use of traditional mechanical compressor chillers supplied by electrical energy, constitute the main basis strategies currently used in DHC systems.

Hot and cold deliveries are managed by substations in connected facilities and homes. Both kinds of these described technologies as well as the resulting DHC combination of them emerge as a feasible and consistent district energy (decentralized, locally generated and used energy) alternative, that have been broadly exploited in Europe, Russia and China in the last century due to their reliability and ease of operation for consumers and their relatively low cost (Gang et al. 2016). They are, however, gaining increased interest among others in the European Union policy scene, due to their high EE, exceeding 90% depending on the nature of primary sources, and their low carbon potential. Thus, for example, 93% of the total heat demand in Helsinki is powered by a DH integrated system supplied by cogeneration systems. This is why the EU has ranked the solution adopted in Helsinki as the "*Best Available Technology*" (IEE 2012). Actually, the appropriate EU policy regulations such as the above-mentioned EPBD and the more recent EU strategy on heating and cooling (European Commission 2016), focus on this direction including the deployment of more renewable energy streams (Lake et al. 2017). Werner (2017) concludes in his analysis that DH/DC/DHC technologies have strong potential to evolve towards a fully green energy sourced future tech, shifting our course towards an encouraged more sustainable future.

As advanced at the beginning of the section, the strategic solution adopted by the Tecnocampus Park since the very beginning for achieving a global climate coverage was Tub Verd, which emerged as one of the responses to the Agenda 21 Mataró commitments (a set of initiatives relating to the Aalborg Charter for Sustainable European Cities approved in 2/04/1998) for promoting energy efficiency and the use of renewable energy sources. Tub Verd is indeed a global DHC system that recovers excess energy from two important municipal management infrastructures: the Municipal Solid Waste Management and WtE plant (CTRSUM) and the Mataró Wastewater Treatment Plant (EDAR). The harvested heat energy provided by waste incineration in the form of steam is also used for electrical energy cogeneration (however, note that this cogeneration process finalized in 2014 due to the rate bonus reduction decreed by the Government; see Table 1). In the wastewater treatment plant, bio methane is produced in anaerobic digesters. Organic matter remaining in

Table 1 Energy mix production evolution

Energy production sources	2014 (%)	2015 (%)	2016 (%)	2017 (%)
Steam	31	43	48	63.6
Biogas (green gas)	47	53	47.8	30.1
Natural gas	10	4	4.2	6.3
Cogeneration (electricity)	12	–	–	–

the flow is broken down by the action of living microscopic organisms in the absence of oxygen to produce a methane-rich biogas, also referred to as green gas. This second source of energy, introduces the extra benefit of generating part of the energy mix production from a highly sustainable form of renewable energy. Tub Verd is supplied by a third and last extra source of heat through natural gas combustion when the two preceding sources cannot meet peak demand. To address cool water production, the system uses surplus heat to drive absorption chillers to provide cooling, jointly with mechanical chillers to cover the entire demand. Finally and as can be expected, the final mix selection procedure ensures both demand coverage and the minimization of the environmental impact. Table 1 shows the primary sources of mix evolution during the period 2014–2017.

As can be seen in the above table, Biogas contribution led energy production during the years 2014 and 2015, shifting to second position in 2016 and 2017, but still maintaining a substantial contribution with respect to the global energy mix production and therefore assisting renewable energy sources and also consequently contributing to the reduction of CO_2 emissions.

To conclude the overall implementation description, it should be pointed out that distribution is performed by means of four steel pipes (two for closed circuit hot water and two for cold water) provided with heat insulation for limiting heat losses, and with the water temperatures inside tubes as follows:

(a) Hot temperatures: 80–90 °C; return <60 °C.
(b) Cold temperatures: 6–12 °C; return <12 °C.

3.2 Energy Efficiency Actions

As mentioned in the beginning of the first section, a large portion of energy consumption takes place in buildings, achieving a global average of 40% of the total primary energy supply (Shaikh et al. 2014). Most of such consumption is due to heating, air-conditioning and ventilation systems. These critical data, even becomes more compromised whether taking into account the Mediterranean buildings´ increasingly climate vulnerability due to the global warming. In this sense, much work to improve energy efficiency (hereafter, EE) in this compromised sector has been done, but there is still a large amount of work to be performed with the time horizon of

2020 and beyond. In this respect, the European Union's 2020 target, aims to a 20% enhancement in EE at all stages of the energy chain: generation, transformation, distribution and final consumption.

This subsection describes a set of procedures on the climatisation system carried out on the building TCM1 for reduction in energy consumption during this last stage of the chain. All these applied measures are focused on heating-cooling control system efficiency. The planned actions undertaken were designed following the recommendations laid down in the existing European Directives 2030/31/EU regarding EE and 2010/31/EU on the Energy Performance of Buildings.

The implementation of an automatic system for the disconnection of heating/air conditioning systems in every classroom, lab and office, has been realised. The system easily governed by means of an electronic device installed in every dependence, turns climate system off two hours after start-up. Moreover, a data analysis stage in order to identify correlations between energy consumption and classroom and lab occupancy (by using the ratio of the number of students per lecture and per lab), has been also fuelled by the TCM-LL to be able to appropriately establish a specific correlation between actions and quantitative results. In addition, to provide every classroom and laboratories with a distributed network of infrared active sensors, for the required people presence control, has been also explored. Note that this infrared technology is also applied in the toilets of each building of the Park in order to optimize the use of lighting resources.

Additionally, due to the energy requirements may be significantly different depending on the local context, outdoor climatic and local conditions of the Mataró city, have been taking into account. Thus, a set of specific actions to further improve building energy performance, has been undertaken throughout the period considered. The following briefly summarizes the major ones:

- Implementation of a routine of total stop of the primary circuit of heat pump during the summer period, in order to drastically reduce the energy bill from the Tub Verd supplier company in this period of non-academic activities.
- Installation of solar protection windows based on thermal material, following the standard passive design methodologies (Hermelink et al. 2013; Mazria 1979) for reducing indoor overheating, especially when dealing with glass buildings and similar ones, such as the TCM1 building.

4 Results and Discussion

We present the annual consumption assessment for each year from 2014 to 2017. We have considered that this period is enough to be able to establish a first trend analysis. Consumption values have been directly extracted from energy bills. Tables 2 and 3 respectively show annual consumption from *Tub Verd* to cover heating and cooling requirements and annual consumption per student. Although is broadly known that cooling and heating requirements may vary greatly depending on weather conditions,

Table 2 Comparative of energy consumed for both heating and cooling processes

TCM1 building consumption (MWh)	2013–2014	2014–2015	2015–2016	2016–2017
Heating	189.5	180.8	362.6	242.8
Cooling	720.0	874.7	826.5	1006.6

Table 3 Evolution of energy consumption per student over time in the over TCM1 building

	2013–2014	2014–2015	2015–2016	2016–2017
Number of students	2267	2582	2915	3159
Relative consumption by student (kWh)	401,191	408,792	407,925	395,505

we have not taking into account said parameter in our assessment, in this first stage of the study. Also note that for both analyses, we have taken into account the academic calendar.

When analysing results obtained we can see that energy needs have been almost maintained in this analysed quadrennial period while the number of students has periodically increased, year by year. These final results reveals that the purposed approach formed by the set of actions described in the previous section and carried out during the period covered have led to a significantly reduced energy demand in relative terms (energy required per student) as a result of steadily increasing efficiency. Additionally, the adopted solution assures a feasible scalability process for adapting to the rest of the university buildings in the Park as well as to other HEIs.

Nevertheless, the need of energy consumption monitoring has been identified when dealing with energy efficiency issues in order to verify how well such goals are met. Monitoring activity of the electricity and energy used for cooling and heating consuming parameters will be highly useful in order to acquire information allowing the analysis of energy consumption and the identification of energy saving opportunities that might be introduced in the future. In this respect, an energy monitoring system will be required in the next stage of the present project.

Lastly, as the main body of the literature states in this respect, and as recently restated by Ferrary and Zanotto (2016), the assessment of results exhibited in Table 2 confirms that the cooling process is what constitute the highest energy expenditure of the set of tertiary and administrative modules that make up the TCM1 building of the park.

5 Conclusions

Buildings are central to the European Union's energy efficiency policy, to reach the ultimate goal of the reduction of emissions causing climate change and that highly compromise the achievement of sustainable development.

On the one hand, it is confirmed that the commitment to the use of the technology of the *Tub Verd* to feed the climatic needs of the campus, promoting the use of sources of renewable energy produced nearby and consequently reducing final conventional energy consumption, has been the most appropriate energy approach. Additionally, an objective to divest from fossil fuels and invest in a sustainable and clean energy economy to largely "decarbonise" our energy systems and move towards a low-carbon economy by 2050 has been addressed. On the other hand, actions conducted to address minimization of energy consumption and guaranteeing a comfort level for the building occupants has also been assured. In this regard, the proposed living lab approach has revealed itself as a useful cooperation working instrument for the exploration and provision of future solutions to current energy performance and to promote the inclusion of future achievements in policies and Park governance processes. In summary, we would highlight that the strategies undertaken by the TCM institutional management in an effort to reduce CO_2 emissions and meet new regulatory demands, have been a success. Nonetheless, we have to step up our efforts to fully implement the requirements regarding the medium-term objective of fully achieving the Nearly Zero Energy Building category.

As a final remark, the authors would like to restate the leading role of HEIs as agents of change, for driving actions within the framework of the UN Agenda 2030, fulfilling with their established societal function and contributing for achieving a more sustainable future.

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Composting and Anaerobic Digestion as Biotechnological Alternatives for the Valorization of Used Coffee Ground in University Campus

Isael Colonna Ribeiro, Roberta Arlêu Teixeira, Livia Luchi Rabello, Jacqueline R. Bringhenti and Adriana M. Nicolau Korres

Abstract Despite the increasing of coffee consumption in Brazil and the consequent increase in used coffee ground generation on university campuses, sustainable alternatives for the coffee wastes recovery are still incipient, and more than 90% of this residue is directed to landfills. This paper reports a study under development at a university campus in Vitória, Espírito Santo, Brazil, aiming to evaluate the generation of used coffee ground and the potential for its use through composting and anaerobic digestion. The study is concerned on the generation, collection, and quantification of coffee wastes in the institution, the proposal of reuse alternatives, as well as the estimating amount of waste diverting from landfill, consequently avoiding greenhouse gases. The evaluated campus has about 80 departments and among these, eight are participating since 2014 in the organic waste recovery project, counting about 130 people involved. Results show that around 55 kg per year of used coffee ground were collected from participating sectors and sent for composting. Results obtained so far show this approach as an important proposal for the sustainable use of coffee ground wastes in living labs experiences of this educational institution. Accordingly, this is a good parameter to be replicated in other situations, supporting the implementation of the Sustainable Development Goals.

Keywords Education · Coffee ground composting · Sustainable development

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1 Introduction: The Valorization of Used Coffee Ground in University Campus

The degradation and overuse of natural resources has meant that new sustainable perspectives are devised and put into practice as a way to readjust the equilibrium of existing relations on the planet. Thus, the development of actions focused on changes in the behavior of people seems to be an efficient tool to face the challenge of decentralized organic solid waste management. Educational institutions often face challenges related to the dissemination of knowledge regarding waste reduction habits in spite of being open to new ways of valuing internally generated organic solid waste (OSW).

University campuses are appropriate places to learning and consolidating new practices, especially the sustainable ones. In this context, the Federal Institute of Espirito Santo—Ifes, Vitoria campus, is an adequate generator of organic solid waste, such as food waste and especially used coffee grounds. This characteristic is a reflection of the increasing production and consumption of the beverage in Brazil and all over the world. Despite the growing production and consumption of the coffee beverage, even in university campuses, the importance given to the increase in the generation of the coffee grounds and to the adoption of environmentally adequate practices for the management of this kind of waste, is not as high as it should be.

The used coffee ground is a solid residue generated after the hot aqueous extraction, after its grains have been roasted and grounded, besides the continuous residue generated in the industrial production process of the soluble coffee (Bravo et al. 2013).

Data from the Brazilian Coffee Industry Association indicate that consumption of this beverage in Brazil was 81 L or 4.90 kg per capita in 2015 (ABIC 2015). It is estimated that for each ton of processed green coffee, 650 kg of used coffee grounds are generated, and 2 kg of that same residue is generated for each kilo of soluble coffee produced (Murthy and Naidu 2017). In addition to the volume generated, the concern with the adequate disposal or reuse of the coffee grounds derives from its highly polluting nature caused by the presence of organic matter, which demands a large amount of oxygen to be degraded (Silva et al. 1998).

Within this context, sustainable alternatives for the valorization of this organic solid residue are still incipient. Biotechnological solutions such as composting/vermicomposting and biodigestion appear as methods to add value to the large amount of used coffee ground generated in Brazil. Most of this waste ends up directed to landfills or dumps, leading to several problems. The proper treatment of organic waste directly at the generation site represents an important contribution in the search for planet sustainability. These strategies also promote mitigation of greenhouse gases (GHG) emissions resulting from the transportation and disposal of this waste in landfills, where anaerobic conditions are predominant.

The importance of encouraging composting and biodigestion as sustainable practices in school environments has been gaining prominence. Hence, educational institutions have been working as living laboratories dedicated to developing actions and leading to the diversion of organic solid waste from landfills, sensitizing employees and students, and also reducing costs with fertilizers and other inputs through the use of these sustainable techniques (Kwasny et al. 2016; Gunther and Besen 2010).

Research and experiments carried out in educational institutions are important for municipal authorities since they bring with them the possibility of their use as a tool and pedagogical instrument to develop actions that foster sustainability regarding the management of organic solid waste. The use of these instruments could leverage a more agile and innovative change process, in addition to being closer to daily life with greater potential for good results. The participants sensitized by these initiatives may afterwards become disseminators of this knowledge in other places.

This study is an experience report of developed actions between the years 2012 and 2017, focusing on adding value to organic solid waste, especially used coffee grounds in different departments at Ifes. This approach is an important experience within the proposition of actions aiming at greater effectiveness in the treatment of organic waste directly in its place of generation. The strategy reported here may be replicated in other corporations that aim at sustainability in the management of their processes, and it can contribute to the adoption and dissemination of good environmental practices in higher education institutions. It is also hoped to support the Zero Waste strategy and the concept of the Circular Economy that has recently been gaining prominence in the scientific environment, highlighted as a possible solution in adding value to solid waste.

2 Sustainable Techniques of Composting and Anaerobic Digestion

Composting is a technique defined by Neto (1987) as a controlled aerobic process, developed by microorganisms and carried out in two distinct steps: thermophilic biochemical reactions and humification. This system has the advantages of reducing the waste destined for landfills and the use of the organic matter obtained in different crops. The final organic compound obtained presents properties that improve the crop yield by providing nutrients to the plants and promoting the physical, chemical, and biological improvement of the soil. In addition, in this development stakeholders may use materials available at their own work/study sites.

For Kiehl (2004), composting is a controlled process of microbial decomposition, oxidation and oxygenation of a heterogeneous mass of organic matter in the solid and moist state. It comprises an initial mesophilic phase, characterized by microorganisms that have an intense metabolic activity due to the great contribution of organic matter, presenting a high synthesis of DNA and enzymes. Afterwards, a biostabilization phase occurs, finally reaching the third stage, where humification or maturation occurs, accompanied by the mineralization of certain components of organic matter, such as nitrogen, phosphorus, calcium, and magnesium, which pass from organic to inorganic, becoming available to plants.

A deep literature review by Valente et al. (2009) point out that composting is affected by the interdependence and interrelationship of parameters such as moisture content, oxygen ratio, Carbon/Nitrogen ratio (C/N), the granulometry, and the porosity of the material to be composted, with all the process affected by the adopted management. In the case of composting, there is a need of not only establishing optimal conditions, but also an to face the challenge of the interrelation of these conditions, since each material to be composted has its particularities. In this way, the mixing of several types of organic waste is the most adequate way of trying to balance the C/N ratio and granulometry. Besides providing the necessary nutrients for the microbial development, this will also favor the homogenization of the composting mass obtaining a better porosity which will result in a lower compaction, due to the greater aeration capacity.

Despite the studies that aim to reuse coffee grounds focusing on composting techniques, biodiesel production potential, and the use of this waste as a substrate for mushroom production, Kim et al. (2017) state that there is great potential for this residue fraction reuse in the anaerobic digestion.

Anaerobic digestion, also known as biomethanization or biodigestion, is a process of anaerobic decomposition of organic matter, which means that it occurs in the absence of molecular oxygen (Fernandes 1997). In these conditions, anaerobic or facultative microorganisms promote the degradation of complex organic matter, generating simpler and soluble compounds, assimilable by microorganisms (Chernicharo 2010). This process, besides promoting the treatment of organic waste, generates by-products, such as biogas and a biofertilizer. These by-products can be used for energy generation and as fertilizer, respectively.

Luz et al. (2017) point out that, despite the high lignin content of coffee grounds, there is a great potential for energy reutilization, since it has a large amount of lipids (more than 25%), which are the main substrates to methane conversion. The coffee grounds are a residue with high percentage of volatile solids (VS) in relation to the total solids content (83.5%) (Bizzo 2003). This demonstrates its degradability by the anaerobic route, generating biogas because the higher is the VS content, the higher is the gas generation rate.

According to Luz et al. (2017) the potential of energy utilization of coffee grounds by anaerobic digestion is so favorable that, the production of biogas obtained from this type of waste is similar to the one produced with biodigestion of bovine, porcine, and poultry manure, a technology already consolidated and used worldwide for the treatment and recovery of these wastes (Konzen 2005; Luz et al. 2017).

In the scope of the Environmental Policies of several countries of the world, such as United States, Germany, Spain, Portugal, and Brazil (after 2010), the valorization of waste is essential to promote sustainability and consequently a better quality of the environment. Thus, the recovery of organic waste, both by composting and by anaerobic digestion, is essential to achieve this objective (Karlsson et al. 2014).

3 Sustainable Practices in Higher Education Institutions as Tools for the Achievement of the Sustainable Development Objectives

Song et al. (2015) point out factors such as population growth, accelerated urbanization, economic expansion, and rising standards of living as the main causes of increased solid waste generation worldwide. Organic wastes is about half of the municipal solid waste generated in Brazil and can be treated on a variety of scales to the production of organic compost (Brazil 2010).

Although the organic leftovers correspond to a significant portion of the solid waste generated, the actions for treatment and recovery of solid waste, commonly adopted in the country, prioritize the treatment of other types of materials. Thus, organic waste is usually not valued and goes to disposal in landfills or dumps often leading to problems of both environmental and sanitary nature (Brazil 2017). Currently in Brazil less than 3% of solid urban waste is destined for recycling through techniques such as composting and anaerobic digestion, reinforcing the fact that promoting the recovery of this waste is among the greatest challenges for the implementation of the National Solid Waste Policy (ABRELPE 2016).

Higher Education Institutions (HEI), which host several activities with educational and environmental interfaces, can act as living labs, being suitable sites for the study and implementation of projects that contemplate composting and biodigestion as modalities for the reuse of organic solid waste. Some HEI have worked on scientific initiatives related to the administration and valorization of this type of waste, and these researches have emerged as important tools of environmental management regarding the scope of sustainability (Costa et al. 2016; Souza et al. 2017).

Among the main challenges related to adding value to the organic solid waste directly in its place of generation, it is worth mentioning the educational persuasion of the public that attends these environments. People's awareness must occur in the most diverse possible ways, since the conviction and participation of the population is a determining factor in the successful implementation of decentralized organic solid waste management systems.

Regarding environmental issues, Guimarães (1995) states that environmental education must be continuous, multidisciplinary, integrated within regional differences, geared to national interests, and centered on the questioning about the type of development we want. The same author establishes that this form of education has the formation of a collective conscience in the individuals as a primary goal allowing individuals of discerning the environmental importance in the preservation of the human species and, above all, to stimulate a cooperative behavior in different levels of intersocial relations.

At this point, education is no longer seen as an end in itself, but as a means to achieve a major goal: sustainable development in all sectors of activity (UN 1992). Since sustainable development is "one that meets the needs of the present without compromising the ability of future generations to meet their needs", it is essential that it be discussed locally "think global—act local" (WCED 1987).

In September 2015, at the UN Summit on Sustainable Development, the seventeen Sustainable Development Objectives were announced, under the name Agenda 2030 (UNPD 2015). These proposals were built between 2013 and 2015 and should guide national policies and international cooperation activities over the next fifteen years, succeeding and updating the Millennium Development Goals (MDGs), as well as strengthening and contributing to the discussion on environmental issues.

These objectives seek to put into practice local actions as a focus on the social, economic, and environmental pillars that are the foundation of a sustainable development. Since these objectives are focused on social health and human health issues, and the recovery of organic solid wastes, through composting and biodigestion in their place of generation make an important direct contribution to pests, vectors and diseases control. Additionally there is a possibility of income generation through the sale of the organic compound obtained.

In this sense, the activities reported and practiced in this research, besides the techniques of composting and anaerobic digestion, fit in a clear way with some of the sustainable development objectives, such as: promoting sustainable agriculture, offering sanitation for all, making cities resilient, and sustainable human settlements, ensuring sustainable production and consumption patterns, taking urgent action to combat climate change and its impacts, and to protect, restore and promote the sustainable use of terrestrial ecosystems. In addition, they also address the basic sanitation aspect of decentralized solid waste management. Sustainable techniques and practices are efficient tools capable of providing better environmental conditions for the planet maintenance in various aspects.

4 Method

The activities developed between the years 2012 and 2017 are part of an experimental research that has been carried out in partnership with the Faculty of Public Health of the University of São Paulo (USP), which had the financial support of Foundation for Support to Research and Innovation of Espírito Santo—FAPES. After the acquisition of six composting equipments in 2013 the activities related to the composting technique began in an incipient method. From the year 2014 on, the selective collection of organic solid waste started to take place in a structured system.

5 Study Area

Currently, Ifes, Vitória campus, has a Biotechnology and Sustainability Laboratory (Labiotecs), Fig. 1. This space was created in the year 2015 due to several teaching, research, and extension activities developed over the previous years with composting and biotechnology topics. Among these actions, in 2012, a research group was formed to study the management of Organic Solid Waste (OSW) on the institution. Among

Fig. 1 Biotechnology and sustainability laboratory (Labiotecs) at Ifes—Vitória campus. *Source* Prepared by the authors

these forms of valorization, the composting technique was chosen to start the study, because the campus has a large number of garden areas.

6 Effective Actions Developed Over the Years 2012 to 2016 and Main Notes

Nowadays there is a growing concern of managers and employees of public and private institutions regarding the implementation and encouragement of sustainable actions. A survey was made aiming to broaden the sustainability interventions, interviewing people of different departments of the campus that would be interested in collaborating with the selective collection of organic waste.

The survey identified the departments and servers interested in participating in the selective collection of organic solid wastes by applying a diagnostic questionnaire between October/2012 and February/2013 Korres et al. (2013). These sectors were mapped through interviews with teachers, administrative technicians, and other employees of the Institution in their workplaces. During these visits, those in charge of the various departments were informed about the project and its objectives, and also invited to collaborate by answering the questions and acting as a multiplier of information to other staff members and teachers.

During the visits, data were collected regarding the consumption habits of organic materials during the business days as well as information on the presence or absence of equipment where these wastes could be stored until the time of collection. These data allowed knowing the types of materials and their generating sources, considering the specificities of the different environments analyzed. The inventory of the organic materials generated in the departments and the types of materials will be used in the assembly and operation of composting bins on the campus. Contributing areas stored the organic waste in plastic containers, provided by the researchers. These containers were conditioned in refrigerators. The containers were collected at different times depending on the department, and had their contents weighed and recorded on control sheets before it was sent to feed the composting binsin the Institution.

Among the departments, eight were willing to participate in the experimental stage of Selective Collection of Organic Residues (CSRO), from 2014 to 2016, including the Campuses Direction. It should be noticed that there was still external participation, that is, some students and staff members involved in the activity brought organic waste from their homes to be used in composting.

It was possible to evaluate, in the described stage, the technical and environmental feasibility of composting practice in the institution, through polls, in addition to monitoring the amount of waste that was generated and collected. At the end of 2016 a thank-you letter for participation was delivered to participants along with a portion of the compost produced. In other activities developed by the research group, such as lectures, workshops, and the Environment Week, a portion of the compound was also donated to visitors, making this practice an academic and pedagogical tool to raise awareness among the participating public.

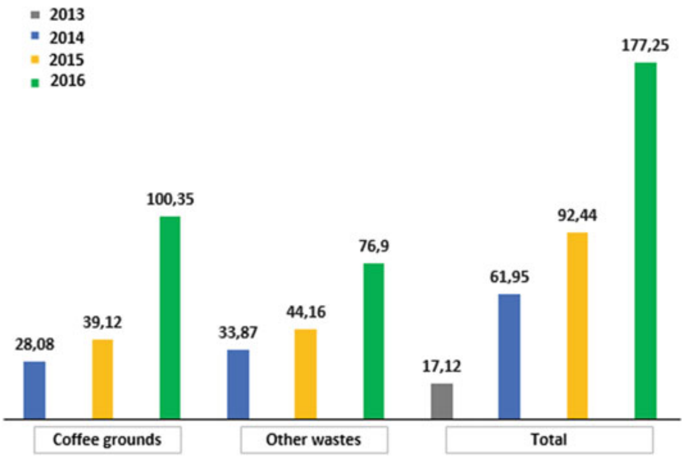
7 Results

Many administrative and educational sectors prepare coffee on campus. Thus, the amount of used coffee grounds could be evaluated during the project, since it was part of the organic wastes collected at the institution studied since the beginning of the research activities. The consolidated data, Graph 1, show the total amount of organic solid waste collected over the years 2013 to 2016.

In 2014, with the structure of the composting practice built on the campus, the collected organic waste began to be separated into two groups: used coffee grounds and other residues, being included in this second category the bark, stems, leaves and leftovers from unprocessed food.

Korres et al. (2013) promoted the awareness and involvement of the school community about the practice of selective organic solid waste collection. They also carried out the survey of those areas of the campus Vitória that generate organic solid waste during the work day. In addition, they encouraged the selective collection of the waste through interviews and the production of information brochures with the intention of establishing the practice of composting in the entire institution. Thus, 26 campus departments were visited in different areas of activity (Teaching, Student/Server Service and Administrative).

In order to reinforce the previously mentioned work, Costa et al. (2016) sought to increase the selective collection of organic solid waste in this same educational institution. They initially mapped the departments in order to determine which generated organic solid waste. Of the 26 areas surveyed, 23 showed interest in performing the OSW and among those interested 11 stated that they perform daily preparation of coffee at the site, noting that they are potential generators of used coffee grounds.



Graph 1 Evolution of the mass of organic solid wastes (kg) collected over the years from 2013 to 2016. *Source* Prepared by the authors

When comparing the evolution of the selective collection process of organic left-overs, Graph 1, there was an increase in the total mass of organic waste collected during the research years and the same increase is also noticed in the quantification of collected used coffee grounds.

In 2013, 17.12 kg of organic waste were collected, and by 2014 this value reached 61.95 kg, which represented a 3.6-fold increase in the mass of waste collected in relation to 2013. In 2014, of the amount of 61.95 kg of collected residues, 45.3% (28.08 kg) were used coffee grounds, while 54.7% (33.87 kg) were other organics. In 2015, a total of 92.44 kg of organic waste was collected and 42.3% (39.12 kg) of coffee waste, the remaining 57.7% (44.16 kg) of other wastes. In 2016, for the first time, the collected value of coffee grounds exceeded the value of other organic wastes, were 100.35 kg of used coffee grounds (56.6%) and 76.9 kg of other residues (43.4%), totaling 177.25 kg of organic waste collected.

The compilation of the data indicates that between the years 2014 and 2016, approximately 167.5 kg of used coffee grounds were collected while the remaining residues reached a total of 154.9 kg, accounting for 322.43 kg of total collected organic waste. Of these, about 187 kg were used for composting/vermicomposting, in the surveys mentioned above, which generated about 136 kg of organic compound. The other residues were used sporadically to maintain the composting systems in order to guarantee the survival of worms used for vermicomposting.

This increase in waste generation, especially in coffee grounds, seems to be the result of a number of factors, among which we can mention: the diversification and increase of the consumption of the beverage, the awareness and the sensitization of the participants in correctly performing the segregation and sustainable destination of the residues, and the strengthening of the research group with the development of new projects and publications. Data demonstrated that activities like these are of paramount importance for the consolidation of an environment with exemplary sustainable practices.

Brazil is the world's largest coffee producer and the second largest consumer (ABIC 2015). Coffee is a widely consumed beverage in many parts of the world, whether in domestic environments, coffee shops or even in institutional environments. Data from the Brazilian Coffee Industry Association indicate that from the year of 1990 until 2018 there was an increase in per capita consumption (kg/inhabitant/year) of roasted coffee in the form of a beverage. The average Brazilian, who at the beginning of the 90s consumed 2.71 kg per year, in 2015 consumed about 4.90 kg. The amount of generated waste is proportional to the amount of coffee consumed; therefore this increase in the consumption of the beverage is one of the contributors to the higher generation of its waste.

The evaluated campus has about 80 departments, of which eight are participating since 2015 in the organic waste recovery project, with about 130 people involved. The results show that about 55 kg/year of used coffee grounds were collected from the participating departments and sent to compost. These values indicate an average deviation of 1.28 kg of used coffee grounds over the three years per person from landfills. If we consider the amount of waste collected, this deviation increases to 2.55 kg. This means that it not only is a sustainability action aimed at improving the quality of the environment and the population in general, but also follows the waste management recommendations proposed by Law of Solid Waste of the country (Brasil 2010).

The popularization and diversification in the consumption of coffee beverage is another factor that probably subsidizes an increase in the generation of used coffee grounds. It should be noticed that this increase in consumption, which translates into a greater generation of waste, is not accompanied by an increase in the concern for adequate and sustainable disposal or use, such as biomethanization.

Another point that deserves to be highlighted is the increase of departments participating in the selective collection, what can be explained by the awareness actions of the participants for the correctly performance of segregation and sustainable destination of the waste. It should be emphasized that the scope of these actions go beyond the walls of the institution, since these activities reach other parts of the community, either through awareness of the relatives and friends of the participants or through lectures, workshops and other events promoted by the Labiotecs research group.

During a year 2016, a total of 58.45 kg of organic waste destined to the vermicomposting process was quantified. Studies on biodegradation of used coffee grounds in commercial coffee shops and university campuses developed by Adi and Noor (2009) demonstrated the importance of the study of the proper destination of this waste.

In this context, another point worth mentioning is the fact that the institution's restaurant did not participate in the survey of departments that generated organic waste throughout the study. This exclusion occurred because the actions were directed to employees and students aiming a reformulation of sustainable concepts in their workplaces. Thus, the work and study prioritized throughout the research the sources of solid organic waste, generation, and collection.

Although not included in this research, the university restaurant is a great generator of organic waste and recently other specific studies involving generation, management, disposal of organic waste, as well as the awareness of visitors are being carried out in this environment.

Over the years, the researchers have contributed to the strengthening of the research group, covering the development of new projects and publications that demonstrate the relevance in the valorization of organic solid wastes in institutional environments. Currently, about 20 students and two researchers are involved in these activities, distributed among undergraduate students in Sanitary and Environmental Engineering and Master's students in the Sustainable Technologies Program. The creation of the Biotechnology and Sustainability Laboratory in 2015 is another aspect that contributed in a decisive way to support the practices of different disciplines and is still used for research and extension actions.

8 Conclusion and Recommendations

The National Solid Waste Policy establishes the importance of reusing organic waste through other useful processes, rather than sending them to the landfill as a final disposal. This action is essential to establish treatment practices that use waste as inputs in processes, promoting the recovery of this type of waste. In this aspect, the used coffee grounds, due to its properties such as biodegradability and high organic matter load, make it an important residue to be valued by the use of sustainable techniques.

The implementation of local actions is a determining factor for the success and the establishment of measures to build a more sustainable planet. In this context, higher education institutions play a fundamental role in the construction of sustainable development, since they can act as living laboratories, supporting the implementation of sustainable development objectives.

The recycling of coffee grounds coming from the institutional environment and recycled in its own place of generation, contributes to the objectives of sustainable development, with the strategy of zero residue and also with the principle of circular economy, since this residue can serve as raw material to the institution, or to another place, being used as fertilizer for the gardens or substrate for planting seedlings.

In general, the research showcase how sustainability actions can be stimulated in higher education environments, also acting as a form of environmental education and propagating sustainable attitudes to the community. The research group has accumulated experience since 2012 with activities of selective collection of organic waste and the destination of this waste to processes of biodegradation, achieving positive results. Those results were published in national and international congresses, initial scientific projects and course completion work for undergraduates, and more recently as project proposals for postgraduate students through a master's degree program in Sustainable Technologies.

Many public and private institutions are great generators of solid organic waste, such as food waste and used coffee grounds, and it is necessary to adopt sustainable practices for its management. The increase in the organic solid waste generation and especially used coffee grounds in higher education institutions as reported in this study, seems to be a tendency to be maintained or even expanded. The treatment of these organics internally in its place of generation emerges as an efficient tool for the solid waste decentralized management.

The used coffee grounds due to their intrinsic characteristics seem to require their own methodology to be efficiently used by the composting technique. International literature has been focusing on this subject, due to the fact that themes such as waste, sustainability, composting and anaerobic digestion are being focused worldwide. In this sense, proposals that seek to evaluate the production of used coffee grounds, the treatments and mixtures of materials that enable the use of this waste in recycling processes, as well as to demonstrate microorganisms capable of metabolizing this material become important in the context of sustainability in institutional settings.

Based on the experience reported, the research group intends to maintain and to expand the selective collection activities for constant operation of the composting bins with greater involvement and participation of students and staff members in the institution. The improvement of the infrastructure of the Labiotecs already approved is being developed and it is fundamental for the continuity of the project, since the institution management support is crucial in all the stages of the process. The efforts of the researchers also move in this direction in order to facilitate external partnerships in order to subsidize new research and analysis, allowing the acquisition of new equipment, the expansion of the research team, new scholarships for researchers, as well as to increase the number of actions in the institutional community and other sectors of society.

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Sustainable Practices for the Organic Waste Management Generated in an Educational Institution Restaurant

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Abstract The recovery of organic solid waste in site represents an interesting sustainable practice for restaurants of university campuses. Since the creation of Agenda 21 and the stimulation of sustainability actions at a local level, educational institutions have become protagonists in the construction of knowledge and sustainable values, being considered laboratories for sustainable practices. In this sense, a case study was carried out at a university restaurant located in the city of Vitória, Espirito Santo, Brazil, with the assistance of undergraduate students in Sanitary and Environmental Engineering, aiming to apply organic solid waste management. First, a survey of all types of organic waste generated in the restaurant was carried out, identifying possible forms of recovery. In addition, the waste management practices performed in the restaurant were evaluated considering the collection, storage, and destination stages. Awareness-raising activities were also carried out among the students participating in the project and the employees of the restaurant, focusing on the management of organic waste and recovery practices. As a result, it is proposed to carry out extension activities with the students, aiming to guide the restaurant users regarding the reduction of waste, as well as raising employees' awareness of proper segregation.

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Finally, alternatives are proposed for the recovery of organic wastes in the restaurant, including composting and anaerobic digestion.

Keywords Restaurant waste · Waste management · Organic solid waste · Composting · Educational institutions

1 Introduction: Organic Waste Management in Educational Institutions

A proper solid waste management is one of the main actions that must be implemented to guarantee the sustainability in organizations. The organic waste management is becoming increasingly urgent, as the water-food-energy link is central to sustainable development. In this context, the International Solid Waste Association recommends implementing practices towards organic waste minimization, acting locally, and avoiding the disposal of waste in landfills (ISWA 2009). This alternative does not promote the waste reuse and requires a large amount of area that can be destined for other purposes, besides generating greenhouse gases (GHG), up to 11% of total emissions GHG in the world.

The vision presented earlier is also used in various environmental policies around the world. The solid waste policy of the European Union, as set out in the Brazilian National Solid Waste Policy (Brazil 2010), states that in the management of solid waste, priority should be given to non-generation, reduction, reuse, recycling and waste treatment, in this order of importance. Finally, if there are no ways of adding value to the waste, the final disposal will be made, with proper execution of environmental controls (Brazil 2010; Juras 2005). Brazilian policy considers that for the management of organic waste, recycling and treatment should be carried out using appropriate techniques such as composting and anaerobic digestion (Brazil 2010).

Composting promotes the decomposition of organic matter using aerobic microorganisms and this results in a stable compound, rich in humic substances, that can be used as soil correction not only in agriculture and in public gardens, but also in residences (Epstein 1997). Haug (1993) states that the organic compound provides the nutrients required for a good development of the plants, increases their resistance to diseases, and ward off possible pathogens.

The composting technique can be performed on a variety of scales, from domestic to industrial. It has low cost compared to other technologies and has been increasingly used in environmental education projects due to its simplicity of application in schools, companies, institutions or in residences, alongside with the possibility of using the compound in green areas already existing in these same places (Paz et al. 2017).

One of the main difficulties with the proper management of organic solid wastes is the alternative often mixed with other types of waste, thus making it infeasible for both organic and recyclable waste such as plastics, paper and metals. Therefore, integrated waste management, since its generation, represents a greater probability of reuse, promoting a more efficient residue segregation, including the possibility of adding value by the generators themselves.

From the 1990s onwards, with the publication of the UNESCO Report on 21st Century Education (UNESCO 1998), and the recognition of educational institutions as a space where knowledge is generated and socialized, and is therefore essential for the awareness, the adoption of good environmental practices in these places has been encouraged. Among these, the creation of sustainability policies, with actions in the socio-environmental scope, has been shown to merge the proposed environmental improvements, often leading to waste segregation practices (selective collection) and reuse.

Among the waste generated in educational institutions, organic waste accounts for more than half of the total, followed by plastic, paper, metal and others (Adriano and Murata 2015; Araújo and Viana 2012; Bochnia et al. 2013; Domingues et al. 2016; Okazaki et al. 2008). Most of this organic waste is generated in their restaurants, independently if the institution itself maintains them or if they are out contracted. This emphasizes the relevance of including the restaurants in waste management policies of these institutions, since they contribute with a large amount of residues, mainly organic wastes (ABRELPE 2016; Adriano and Murata 2015).

In restaurants, the variety and the quantity of food offered usually exceed the need for consumption, with frequent occurrence of leftovers and wastage (WRAP 2013; Naspolini et al. 2009). Thus, the adequate planning of menus and meals is essential for reducing the solid waste generation.

From this perspective, implementing organic waste management actions in students' restaurants leads to sustainability. So, this chapter reports the study about organic waste's valorization developed in the Federal Institute of Espirito Santo, Vitoria campus, with focus on waste management actions. The study was executed with the involvement of students, employees, and managers of the restaurant. Information about waste's generation, packaging, and disposal, was collected. The data was analyzed from a sustainability perspective, aiming to minimize waste, and promoting a recovery by composting technique. Simultaneously, education activities were also carried out among the students participating in the project and the employees of the restaurant, focusing on organic waste management, minimization and recovery practices. After data analysis it was possible a proposition of actions aimed at greater sustainability in the processes carried out within the restaurant, working toward to contribute to the adoption and dissemination of good environmental practices in the institution.

2 Sustainable Practices for Organic Waste Management in Ifes

The Federal Institute of Espirito Santo (Ifes), Vitoria campus, located in the city of Vitoria, Espirito Santo, Brazil, is a public institution of vocational and higher technical education, founded in 1909. Its mission is to promote a professional public education of excellence, integrating teaching, research and extension, contributing to the construction of a democratic, just and sustainable society. The current network of Federal Institutes of the state of Espirito Santo was created in 2008 and has 22 campuses installed in the state, in all regions, with a total of 19,000 students.

The Vitória campus currently has about 4000 technical, undergraduate and graduate students, as well as 293 faculty members, 175 technical-administrative staff, and 80 external collaborators.

The Ifes courses last between 2 and 5 years, and can be offered in three shifts (morning, afternoon and night). Students are admitted every semester or annually, depending on the course and therefore there is a high turnover of people who use the campus. In addition, the large number of campus users contributes to the generation of waste at the site, including organic waste, since most students, employees and external collaborators use the campus during the lunch period.

The existence of specific environmental courses in the campus (Environmental Technician, bachelor in Sanitary and Environmental Engineering and Master in Sustainable Technologies) arouses interest in the practice of more sustainable actions by students and teachers/professors. Among these actions, in 2012, a research group was created to study the management organic solid waste (OSW) on the institution. Among the forms of valorization, composting technique was chosen to start the study, because the campus has a large number of areas with gardens. Small-scale composting as a sustainable practice for the recovery of organic waste has been studied since 2012 at Vitoria Campus. In this theme, several researches were developed, focusing on the evaluation of the composting potential in the institution: small-scale composting parameters, ways to improve the efficiency of the process, and evaluation of small-scale composting to value organic solid waste (OSW) generated in educational institutions (Costa et al. 2016; Korres et al. 2013; Souza et al. 2016).

As a starting point for the surveys, the institution's inventory of organic waste was carried out. Its strategy was to raise awareness and environmental education of the target public, to carry out actions focused on small generators distributed in the various sectors present on campus. Thus, in 2013, the action of selective collection of organic within the campus was initiated. The collected organic wastes were sent to the composting area of the Biotechnology and Sustainability laboratory—Labiotecs (Fig. 1). The study began in an experimental way, being gradually extended, and currently the main objective is to include the restaurant of the institution within the actions of the project.

Small-scale composting has the same goal of large-scale composting, which is to degrade organic matter, generating a compound, which can be used in soils. However, on a small-scale, vertical boxes (Fig. 2), which may or may not contain earthworms,

Fig. 1 Labiotecs composting area. *Source* Prepared by the authors

Fig. 2 Compost used for small scale composting. *Source* Prepared by the authors

are used to aid in the degradation of the compound, acting on aeration of the material and easily eliminating odors (Kiehl 2004).

This technique is an important environmental education tool, since the generator of the waste accompanies all phases, from production to the use of the compound. Thus, this process has great potential for dissemination to the population, acting as a complementary technique to large-scale composting (Maragno et al. 2007).

Another positive aspect of small-scale composting is that it is less susceptible to contamination by other materials, since usually the residues used are generated at the place where they will be used (Brito 2008).

Labiotecs was created in 2015 and aims to provide structure support for conducting research on this topic. Several works of undergraduate scientific initiation and final projects have already been done with this theme. Currently, three master's dissertations are being developed in this laboratory. In addition to the research, extension activities and workshops are held with other schools around Ifes. All the activities were focused on discussing and disseminating the composting technique and waste recovery.

The potential of the biotechnological use of OSW by composting was tested and the conclusion is that the approach is completely adequate. In the current phase, the restaurant inside the institution is by far the point of greatest generation of OSW and studies are being carried in order to include it in the research.

3 Method Description

The study was carried out in a restaurant located at Vitoria Campus—Ifes. The stages of the study comprised:

(1) Initial assessment of restaurant waste management;
(2) Organic waste sampling;
(3) Educational actions in relation to waste management;
(4) Proposing actions to improve the sustainability of the restaurant.

(1) Initial assessment of restaurant waste management

To evaluate restaurant's initial situation in relation to waste management, a visit to the restaurant was held to explain the aims of the study and to verify employees' interest in taking part of this research. In this first visit, it was observed how the day-to-day activities were developed, the restaurant's infrastructure and the flow of waste generation. It was verified that the restaurant was formed by different environments, as shown on Fig. 3, by:

- Larder (food deposit);
- Materials storage (plastic bags, containers by styrofoam and plastic);
- Kitchen area (cooking and food preparation) (Fig. 4);
- Administration room;
- Bathroom;
- Customers attendance and dining hall (Fig. 5).

In addition to these, there is an external area, sidewalk, with access outside the institution, where the collected waste is initially disposed, before being collected by the city waste truck. This area was used during this research to collect the different types of waste studied (Fig. 6).

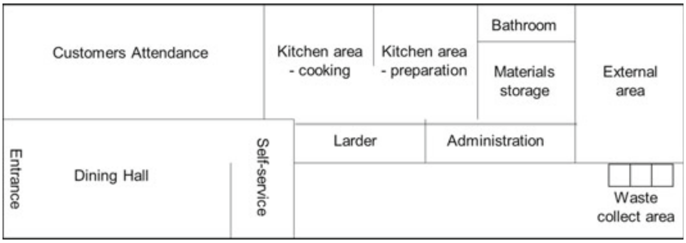

Fig. 3 Restaurant's layout. *Source* Prepared by the authors

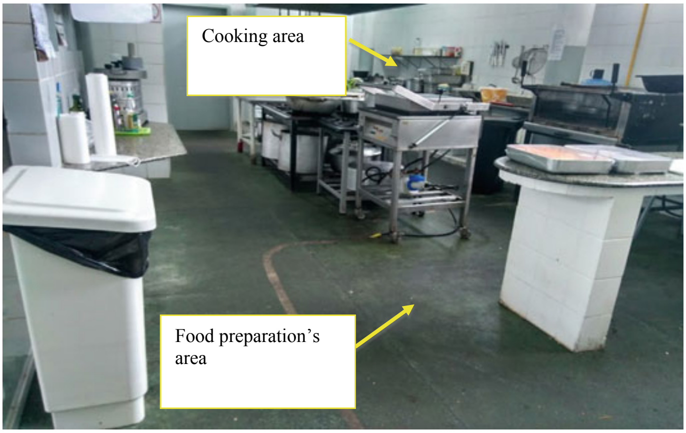

Fig. 4 Kitchen area. *Source* Prepared by the authors

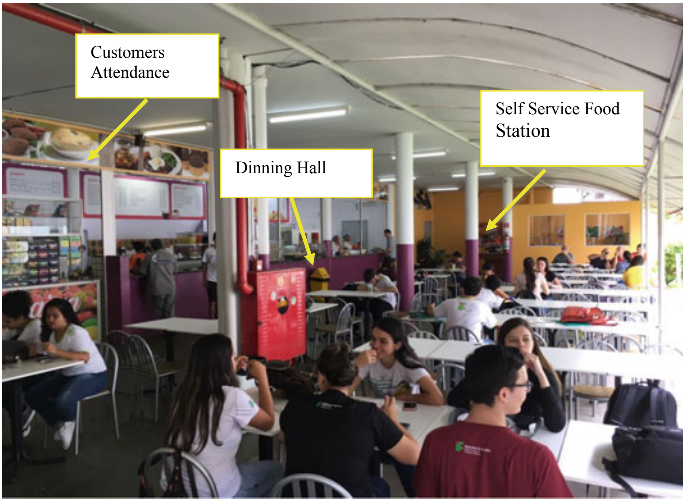

Fig. 5 Customers attendance and dining hall. *Source* Prepared by the authors

Fig. 6 Waste disposal area. *Source* Prepared by the authors

Also, it can be verified that the restaurant, at the time of the study, operated from Monday to Friday, from 11 to 14 h, and had two staff responsible for preparing meals.

As the response was positive regarding the restaurant's participation in the study, the work started with an explanation about the relevance of the study, importance of sustainable practices in educational institutions and the problems related to organic solid waste. Employees were also instructed on how the study would be developed. After this initial survey, it was possible to understand the flow of activities performed to produce meals in the restaurant, and how the waste was generated.

(2) Organic waste sampling

After analysis of the waste generation's flow it was defined which types of wastes would be segregated, according the stage of waste's generation (preparation, post-cooking, or rest-ingestion), also considering the possibility of reutilization by small-scale composting technique. This was possible due to the existence of a research group already established, and with a lot of experience in this subject in the institution. Figure 7 shows the types of waste collected.

The organic waste sampling was carried out for 10 days (from September 12 to September 25, Monday to Friday). In this stage, organic wastes were collected in containers, after segregation by restaurant staff (Fig. 8). The number of meals served per day during the evaluated period was also recorded, in order to provide subsidies for the evaluation of possible wastage.

It was observed a prior division of tasks in the restaurant during the preparation of the meals. While one station was responsible for cleaning and preparing meats, other was peeling and preparing fruits and vegetables. It was defined that the collection would be in accordance with this division. Thus, the collection proceeded, and the wastes were segregated in different categories as: meat processing waste, vegetable and fruit peels, vegetable leaves and stems, and, lastly, other vegetable wastes. After consulting the relevant literature, it was found that this form of separation makes

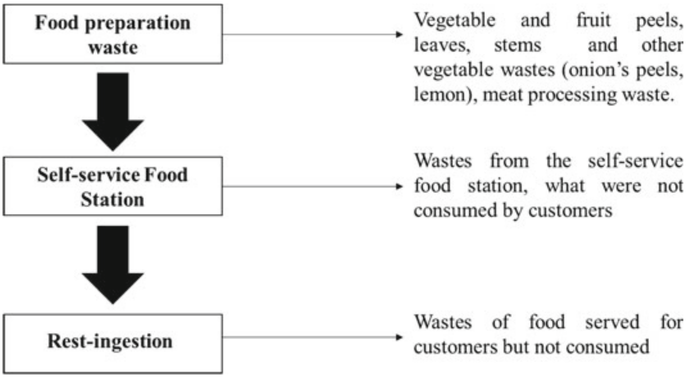

Fig. 7 Type of wastes studied. *Source* Prepared by the authors

Fig. 8 Kitchen area. *Source* Prepared by the authors

easy the use of waste for composting, once the use of meat waste is not favorable for small-scale composting (QUERCUS 2017).

To increase the reliability of the collection, the residues were placed, per container, on a canvas (Figs. 9 and 10), and a visual inspection was performed to check the presence of wrong type of waste, such as presence of lemon in container of vegetable and fruit peels wastes (Fig. 9). If the mistake was confirmed, the residue was withdrawn and inserted into its respective container.

After collecting the containers, the waste was weighed in an accurate scale, Marte™ model LS 200, with capacity of 200 kg and a resolution of a gram. The mass and volume of each empty vessel were known. In addition to the mass of the residues, the volume occupied by them was estimated, and both data were recorded in a control worksheet. The number of meals was also registered through the data provided by the restaurant managers.

Fig. 9 Vegetable and fruit peels. *Source* Prepared by the authors

Fig. 10 Wastes from self-service food station. *Source* Prepared by the authors

(3) Educational actions in relation to waste management

Every day the restaurant's employees were asked about the main difficulties in the collection process, besides being instructed on minimization, reuse and proper disposal of solid waste. The employees' perception of the activity was also recorded. Although, when there were gaps in the collection, such as the presence of different types of mixed residues in the containers, employees were alerted, and educated about the importance of segregation.

Parallel to the collection of waste, an explanation was made to the workers about composting technique as an alternative for waste recovery. Concepts about the technique, types of residues that can be composted, and demonstration of composting were approached, and employees were also invited to visit the small-scale composting area of Ifes.

(4) Proposing actions to improve the sustainability of the restaurant.

After the initial evaluation, wastes' collection and sampling, possible actions were identified to contribute with restaurant's sustainability, which will be presented in a next stage, to those responsible for the management of the restaurant, and their employees.

3.1 Main Results

After a first visit at the restaurant under study, information about its solid waste management was collected. At this stage it can be verified that most of waste produced was discarded, without adding value. Only cooking oil was separated and donated to an institution which makes soap, something that demonstrated the interest of the restaurant's manager in promoting sustainable actions, that also can be allow economic return to the company.

It was identified that most of the wastes were generated in the period between 11 a.m. and 2 p.m., withdrawn for collection in containers at 4 p.m. and collected between 5 p.m. and 6 p.m. Both container volumes and accumulation storage time, as well as accumulation storage local, were considered appropriate.

In relation to internal containers for waste, these also were considered adequate. They were close to the employees' (in the preparation of meals), and in the customer service area to dispose of the waste produced. It is important to note that restaurant did not have a fixed menu, which made it difficult to analyze types of waste generated, so, it was choose a more general analysis, as mentioned in the previous section.

Regarding the perception of the employees about the waste management, it was verified that since the restaurant did not have a systematic plan to minimize waste, segregation and valorization, these actions were not perceived by the employees as important for their activities. This highlights the importance of a management that aims at minimizing and adding value to the solid waste generated, including organic waste.

In the sampling stage, a qualitative and quantitative evaluation of the generated residues it was performed, as shown in Table 1 and Fig. 11.

About the types of residues generated and their quantities, it can be verified that residues of cooked foods (both self-service food station and dishes) represented the highest percentage among collected residues (46.4%) (Table 1), evidencing the occurrence of wastage in food production (by the restaurant management) and/or consumption (by customers).

Table 1 Average amount generated of each type of waste in the evaluated period

Types of organic waste	Average quantity generated (kg/day)
Vegetables peels	3.27
Leaves and stems	3.92
Meat	1.08
Other food preparation wastes	4.3
Rest-ingestion	1.13
Self-service food station	9.77
Total	23.47

Source Prepared by the authors

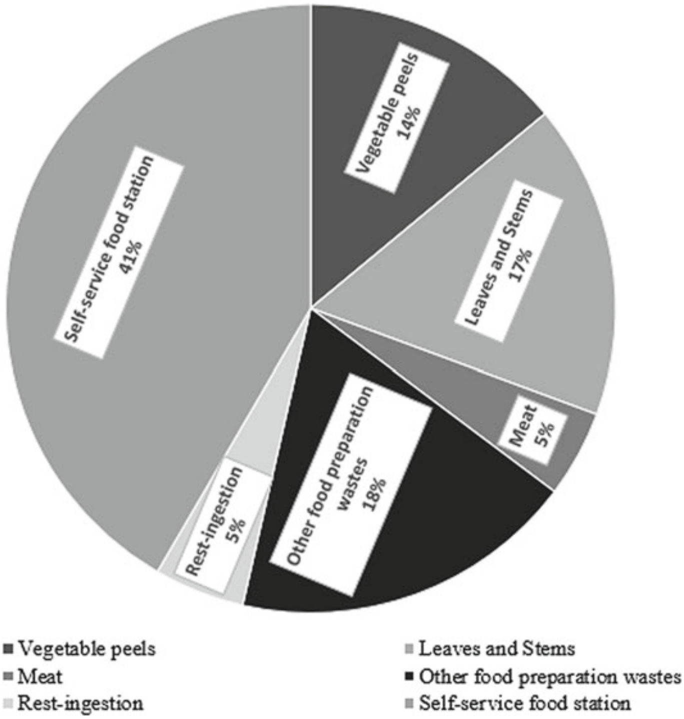

Fig. 11 Type of wastes studied—representativeness. *Source* Prepared by the authors

Table 2 Results' distribution of waste sampling

	Week 1		Week 2		Average (kg/day)	Standard deviation
Days of week	(kg/day)	Number of meals	(kg/day)	Number of meals		
Monday	22.58	135	22.00	136	22.29	0.41
Tuesday	22.92	176	25.22	146	24.07	1.63
Wednesday	22.75	168	25.54	148	24.145	1.97
Thursday	27.70	164	19.68	147	23.69	5.67
Friday	20.18	135	26.14	130	23.16	4.21
Total	116.13	778	118.58	707	–	–
Average	23.24	156	23.77	141	–	–
Standard deviation	2.74	19.30	2.77	7.96	–	–
General total (During 2 weeks)	Total of waste (kg)		Number of meals		Average (kg/day)	Standard deviation
	234.71		1485		23.47	2.61

Source Prepared by the authors

Table 2 shows the total amount of organic waste generated on each day of the evaluated period. It can be observed after statistics analysis that on the first three days of the week (Monday, Tuesday and Wednesday) there is no great variation between the amount of organic waste generated in the restaurant, as can be observed by the value of the standard deviation, in these days, in the two weeks of study.

This similarity in the amount of waste generated per day reflects the absence of a specific day for food "pre-preparation" activities, such as vegetable cuts and meats for storage and subsequent use, as confirmed by those in charge of restaurant management, considering that there is no weekly planning for the development of related activities.

As for the days of Thursday and Friday, the values were more discrepant, with a standard deviation between 4 and 6. It is assumed that in these days parallel events usually occurred in the same time of usual classes, contributing for an increasing number of restaurant's customers. It can still be verified that some postgraduate courses only have classes in these two days a week, which also seems to contribute for this consumption increase and by consequence for the amount of wastes generated.

Compared with data about number of meals served in each day, it is observed that the average daily number of users who attended the restaurant during the collection, for lunch, was 150. According to data by Zotesso et al. (2016), each user of a self-service restaurant puts 730 g of food per dish, and average total's waste by dish can be estimated as 7.51 g (approximately 1% of total consumption). It indicates therefore that wastage was not occurring on the part of the customers. However Naspolini et al. (2009) and Martins et al. (2006) in their studies verified much higher values of waste in relation to the rest-ingestion, being discarded of 100–150 g of residues, per dish, daily in the universities studied by these authors.

Another issue is about wastes on self-service food station. Food produced, conditioned in the self-service food station, but not consumed turns into waste, and cannot be reused for feeding customers thus being discarded. These residues account for 41% of the organic waste generated in the restaurant. It demonstrates a failure in the planning of restaurant management, since it produced much food than was not consumed by customers.

Zotesso et al. (2016) affirm that in restaurants with a fixed-rate distribution, the percentage of leftovers reflects mainly the efficiency of planning the quantity of preparations in relation to the number of meals to be served. These same authors carried out a study on the generation of waste at a university restaurant in the state of Paraná, Brazil, and found that the percentage of food waste prepared and served to customers ranged from 13.3 to 16.4%. These values were like those of Ricarte et al. (2008), in a university restaurant in the state of Ceara—Brazil, where the percentage of surplus was 11.65%.

In this way, it is verified that a re-adaptation of the current planning in the restaurant is necessary to reduce this observed disparity. Thus, restaurant management should do a study the average amount of consumers per day, and so determine the production based on these data. In this way it will be possible to avoid the production of an excessive amount of meals, and consequently of generated waste.

It is still possible to adapt the menu according to the preference of the customers, in addition to using inputs of the time, to reduce the environmental impact of the restaurant activities.

Also, it is important to emphasize in relation to the preparation residues, that many deteriorated foods were present, again indicating a fault in the meal planning, resulting in a too-large purchase of products incompatible with the production of meals. At this point it can be observed residues of leaves and stems represents 16.7% of total waste, and waste type “other”, 4.3%, this represents a total of 21% of generated waste, which, the most part it was “spoiled” (Fig. 12). In addition, it was found that many foods were discarded, but there were no indications of any problem that might affect their consumption (Fig. 13).

These factors also highlight the importance of making employees and administrators of the restaurant aware of food waste and the possibility of reuse of waste.

The results obtained from waste sampling were similar to those obtained by Venzke (2001), in a study about waste’s generation of a restaurant located in an automotive industry, showing a pattern in the generation of waste from large institutions. Venzke (2001) in his study, verified that the main contribution of residues comes from the hygiene of fruits and vegetables. This is due the proceedings performed in this stage, where food is peeled, cut and washed. Among the reuse alternatives that can be considered are: composting and anaerobic digestion, cited as adequate techniques for the use of organic waste by the National Solid Waste Policy (Brazil 2010). The use of anaerobic digestion proves to be quite interesting in view of the large amount of food residues already prepared and which can be detrimental to small-scale composting.

Fig. 12 Spoiled foods. *Source* Prepared by the authors

Fig. 13 Food without evidence of deterioration. *Source* Prepared by the authors

However, since the institution already has a composting area, the large amount of waste generated in the preparation can be used for composting (peels, leaves and stems), which corresponds to 30.6% of the total waste generated. It is suggested the segregation of these residues and redirection to the composting in the institution. At the same time, it is suggested the practice of actions to reduce waste in the production/preparation of food, thus reducing the amount of waste from the self-service bench.

Another factor to be observed is the presence of gardens in the studied institution, that generates residues from tree pruning, weeding and sweeping, which could be harnessed by means of composting with organic waste. Souza et al. (2016), in a study on the feasibility of composting waste from a university restaurant, concluded that this can be done successfully, using RSO produced in the restaurant, together with the waste from gardening, due attention to the proportions of C/N, to be used, and to carry out the adequate monitoring of the composites.

Suggested actions for better management of restaurant waste (cited in this chapter) will be sent, in a document, to the administration of the restaurant in order to contribute to sustainability in the institution studied.

Regarding the perception of the students participating in the project, it is possible to verify their great interest in applying the knowledge acquired in the classroom in the waste management of the institution's restaurant. The experience proved to be satisfactory for 100% of the students. As for the waste in the meals, by the generation of residues of the rest-ingestion type, the students proposed the realization of awareness actions with the school community. In addition, students were interested in contributing to the management and valuation of waste generated in other places, seeking to replicate the experience developed.

For the employees of the restaurant, the survey showed a 100% satisfactory rate, however there were some difficulties with regard to the suggested changes, which influenced the employees' work routine. In order to overcome this problem, workshops were held to raise the awareness of employees and those responsible for the restaurant about the importance of waste segregation for adding value, as well as the implementation of sustainability actions that may bring environmental and economic benefits.

After the workshops and the delivery of the results of the study, a new evaluation of the perception of the employees of the restaurant was carried out, verifying that there was greater interest in the continuation of the project, considering the benefits obtained from the institution, mainly in the segregation of organic waste for composting.

4 Conclusion

This study was able to verify that the development of sustainability actions in educational institutions is valuable for the creation of an environmental conscience on the users of the institution. In addition, it is shown as a teaching tool to students who can put into practice the lessons learned in the classroom, contributing to the maturing of knowledge.

The adoption of appropriate practices for solid waste management is essential for the maintenance of environmental quality and should be implemented in institutions. Composting is shown as an adequate alternative for both waste treatment and recreational teaching, contributing in the process of environmental awareness and dissemination of sustainable practices on university campuses.

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Sustainable Alternative Water Sources Use for Lowering Cost Pressure on Drinking Water and Volume Reduction—Technical and Profitable Feasibility

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Abstract Due to the growing scarcity of water, and the persistent high energy cost applied to drinking water, this study aimed to analyze the potential use of alternative sources of water like rainfall water and roofs drainage system, designed to combine with condensed water production of the air conditioners, at Federal Institute of Science and Technology of the State of Espírito Santo, Brazil. Quantity and quality variables and parameters were measured on collected samples, and an evaluation process of the technical and profitable feasibility has been developed. The method is focused on water demand for different daily use, rainfall water from roofs drainage, measurements of dripping water from air conditioners, and sampling from both sources for chemical analysis of water quality. The results obtained from the experimental area designed for the study show a daily demand of water estimated at about 7,723.00 L.

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The rain drainage flow from roofs area was calculated, and equal to 177.81 L/min. The volume generated by air conditioners was estimated, equal to 289.36 L/day. All parameters for water quality remain standardly good so that water can be used for gardens irrigation, floors and rooms washing, so that preserving drinking water. The study demonstrates economic value of use of the alternative water resources and that sustainable based actions are at reach of any academic center.

Keywords Water use · Roofs water drainage · Alternative water resource · Water quality · Water sustainability

1 Introduction

Over the centuries, excessive use of water resources and permanent withdrawals for various purposes have considerably reduced water availability and have produced numerous shortage problems in many regions of the world (Tundisi 2009).

Man's survival is related to his ability to reuse scarce resources, particularly water, as well as its protection, recovery and reuse (Mancuso 2003).

Matching the Sustainable Development Goals (SDG) and with the goal of achieving the Millennium Development Goals, a substantial change in society's production and consumption patterns is required. Water conservation practices provided by the control of increasing demand with the expansion of water supply, using alternative sources of water, such as the use of rainwater, can be defined as a set of practices, techniques and technologies that improve the efficiency of water use (Gonçalves et al. 2006, p. 45).

The National Environmental Policy Program (A3P) (Brasil 2009) and the Environmental Management Program (PROGEA) of the Federal Institute of the State of Espírito Santo were stimulated by the National Water Resources Policy (Brasil 1997), as a social and environmental management programs carried out by private companies and public agencies, looking for ways to recycle the water used in buildings or collect rainwater for use in cleaning, gardening and depletion.

The Municipality of Vitória promulgated in 2007 the Program for the Conservation, Reduction and Rationalization of Water Use in Municipal Public Buildings with the objective of "establishing measures that stimulate the conservation, rational use, and use of alternative sources for abstraction of water in new public buildings, as well as the awareness of users about the importance of water conservation" (Vitória 2007).

Rainwater, although a random occurrence resource, can be collected with the purpose of meeting some basic demands, and in arid regions, this is an important source of water for families. Other unconventional sources of water utilization may be related, for example, to refrigeration appliances. The use of dripping water from air conditioning equipment has been of major concern in recent years, since the volume generated daily, regardless the rainfall occurrence, may have less noble uses, allowing treated water to be allocated for the more important activities.

Considering the importance of developing research related to the use of rainwater and water generated by air conditioners, the present study carried out at the Federal Institute of Science and Technology of the State of Espírito Santo (Ifes)—campus Vitória, pointed out the possibility of using alternative sources with satisfactory results in the economic and environmental scope for the Institution.

This study is justified by its application in a teaching institution as a sustainable approach because of the support of the Laboratory of Biotechnology and Sustainability (Labiotecs) that is a new and important area for the Undergraduation Course of Sanitation and Environmental Engineering, contributing to the thinking and decisions policies on sustainability in the Institution as a whole, that aim to foster new technologies to reduce the use of treated water for non-noble purposes.

This chapter presents a case study of the potential and feasibility of using rain water drained from roofs and water produced by air conditioning equipment, experiment designed and installed close to the Laboratory of Biotechnology and Sustainability at the Institute of Science and Technology of the State of Espírito Santo, Ifes—Campus Vitória, and aims to demonstrate the water economy through sustainable management of water resources.

2 Sustainable Management of Water

One of the strategic activities for the management of water resources is the assessment and appropriation of the dynamics of water availability in the river basins together with the demands for the various uses of water. This activity has as main product the Water Balance disclosed in the programs and Plans of Basins. The balance between the supply of water and the quantitative (withdrawn) and qualitative (effluent releases) demands is of fundamental importance to trace the diagnosis of the watershed, method based on guidelines of the Brazilian Water Resources Agency (Agência Nacional de Águas 2016).

The state of Espírito Santo presents a dry climate, which is characterized by negative water balance ranging from −50 to −550 mm per year, in about 68% of its area, concentrating in the Northern and Northwestern regions. However, they are also few regions in the southern with low rainfall pattern. The remain area of the state (32%), presents a rainy climate with positive water balance, ranging from + 50 to +1,000 mm which is concentrated in the Serrana Center-Southern region, at altitudes normally above 400 m (Incaper 2016).

It is noteworthy that the climatic changes occurred in the last decades have generated changing in the pluviometric pattern in Espírito Santo. Silva et al. (2012) states that there was an evident change in the rain pattern in the municipality of Vila Velha, between 1970 and 2011, whose analysis showed a considerable reduction in the monthly and annual frequencies of daily precipitation events, and there was a relative increase of heavy rains.

To face the water stress and shortages that have been occurring over the last decades, alternatives of management are sought to reduce wasting and to make better use of alternative sources of water resources for human restricted use.

The concept of rational use for water conservation consists of the association of management not only with demand but also with the supply of water, so that less noble uses can be supplied, whenever possible, by water of inferior quality (Oliveira et al. 2007, with Lemos et al. 2009). The substitution of water sources is shown as the most plausible alternative to satisfy the less restrictive demands, releasing water of better quality for nobler uses, such as domestic supply. In 1958, the United Nations Economic and Social Council established a management policy for areas lacking water resources, which supports this concept: "Unless there is great availability, no good quality water should be used for uses that tolerate waters of inferior quality" (ANA; FIESP; SINDUSCON-SP 2005).

According to Weiner (1987, with Figueiras 2013) the use of rainwater harvesting systems for human consumption has been used in several parts of the world and in several continents for thousands of years. These catchment systems were mainly used in semi-arid regions, where rain season is very short, just covering few months of the year. Another way to deal with the scarcity of water supply is to drain water from systems of refrigeration, depending on the quantity of equipment, power and time of use. The air conditioner is a device that aims to treat the air of an environment, providing conditions of temperature and humidity ideal for the human being, being designed to provide thermal comfort to an enclosed environment and to be installed in windows, walls, houses of machines, among others (Gonçalves 2005; Rigotti 2014).

The air conditioners promote the generation of water resulting from condensation, which is often lost to the soil or to the sewage. In this way, the use of this water depends on the efficient collection of each drainage system of the devices that can be directed to a collection and storage system (Rigotti 2014).

3 Methodology

The Federal Institute of Science and Technology of Espírito Santo—Campus Vitória (2008) was initially conceived as the School of Apprentice and Craft of the Espírito Santo, which was created on September 23, 1909—having received in the meantime the names Technical School of Vitória (1942), Federal Technical School of the Espírito Santo (1965) and Federal Center of Technological Education of the Espírito Santo (1999). The Institute is located at Avenida Vitória, number 1729, in the Jucutuquara neighborhood, in the center of the island of Vitória (Ifes 2017). Vocational technological education is of great importance for economic and social development in Espírito Santo, and for this reason and its excellence in technological education, the Federal Institute Network across the State is tightly linked with the local production system and economy.

4 Experiment Design and Methodology Settings

The project used for this study includes the area of two pavilions (Block-D and Block-G) next to the Laboratory of Biotechnology and Sustainability—Labiotecs/Ifes—Campus Vitória, which is integrated with nature, where teaching, research and extension activities are carried out, such as composting and minimization of organic waste. The roof area and detailed information about the rooms of both pavilions covered by the experiment were collected from the physical plant archives of the Vitória campus, obtained together with the Engineering and Maintenance Coordination of the Institution. The dimensions and area of the gardens near the Labiotecs were obtained by practical survey with technical measurement instruments.

A survey was conducted on the use of each room in the corridors covering the study. Information on the number of people per room, number of devices, power and frequency of use were collected in order to obtain a standard of use of the air conditioners.

An inspection of the roof of Block-D was carried out in September 2016 to identify rain gutters and pipes, as well as obstructions along the flow path that can lead to decreasing discharge of the drainage system or changes in the quality of collected water.

According to Tomaz (2009), it is necessary to know the specific consumption by all activities to determine the viability of the use of stored water, since certain activities require a higher or lower level of potability for the system to be efficient. Based on the subjectivity of the employees' answers about water consumption in the Institution, we chose to use the consumption by area presented in the technical bibliography.

The main methodological steps are summarized as below:

- Diagnose the study area to determine potential sustainable water sources for collection and drainage, and reservoir location.
- Estimate the volume of rainwater through the characterization of the rainfall regime of Vitória.
- Estimate the volume of water produced by the air conditioners located in the study area.
- Analyze the collected water quality in relation to total coliform parameters, free residual chlorine, apparent color, pH, total suspended solids and turbidity in the laboratory, separately for rainwater and air conditioners.
- To size and study the technical and economic viability of a system for collecting and using rainwater and air conditioning devices.

To obtain the rainfall intensity, it is a very usual way to express the intensity-frequency-frequency-IDF relations, which are expressions obtained from frequency distribution adjustments. For our case, the city of Vitória, the following IDF equation was used:

$$I = \frac{4{,}003.611 \times T_r^{0.203}}{(t + 49.997)^{0.931}}$$

Being:

T_r Return period, in years;
t rainfall duration time, in minutes.

After the study of the physical plants of the place, together with the information obtained in the visit to the roof, it was considered that the area of contribution is composed of inclined surfaces (tiles) together a flat and vertical mixed surface formed by the gutters.

The project flow was obtained based on Associação Brasileira de Normas Técnicas -NBR 10.844/1989 (Technical Standard NBR 10.844/1989), and calculated by the following equation:

$$Q = \frac{C \times I \times A}{60}$$

Being:

Q project flow, in l/s;
C flow coefficient;
I Rainfall intensity, in mm/h;
A Contribution area, in m^2.

The original discharge of rainwater was carried out directly in the soil of the Labiotecs and a change was made in the direction of the pipe that arrives at the Laboratory, so that the flow was directed to the nearby wall, at a height that allowed its collection (Fig. 1). This simple change allowed not only a sample with less external influences, but also reduced the occurrence of flooding in the waterproof area of the laboratory.

All air conditioners in the experimental area between the two pavilions and the Block-E were prospected, considering both the ground floor and the upper deck. The air conditioners devices were arranged for the study according to the brand and model. Thus, sampling procedures were applied to some unities of the same models, and this allow to create an average of quantification of the generated water volume and of the quality of the same.

Two different methods were used to collect samples of water discharged from the air conditioners:

(1) The first method consisted in placing containers below the apparatus located on the ground, so that the water generated was collected.
(2) The second method was possible from October with the use of a rugged polyvinyl chloride (PVC) pipe, two 90° curves, three 45° curves and three T connectors; it was possible to connect the four Haier models located on the upper deck next to the Labiotecs and to carry out the samples reducing the external interferences as illustrated in Fig. 2.

From the average flow calculated for the five models in the study area and the number of devices for each model considering the average daily usage time, it is possible to estimate the daily or weekly volume generated. Laboratory analyzes were performed according to the methodology presented by the Practical Handbook on Water Analysis prepared by the FUNASA—Fundação Nacional de Saúde (National Health Foundation), Brasil (2013), in the Chemistry Laboratories (free residual chlorine, apparent color, pH, total suspended solids and turbidity) and of Microbiology (total coliforms and *Escherichia coli*) from the collection of three samples for each source.

The study proposes the use of a water volume, both generated separately by air conditioners and rainfall, which is not currently used on the campus. Thus, the opportunity to foster an environmental awareness in the Institution regarding the use of alternative water sources and the rational use of water resources is envisaged.

In this sense, observations were made to assemble the final system, contemplating both rainwater and water generated by air conditioners. The prices of the materials

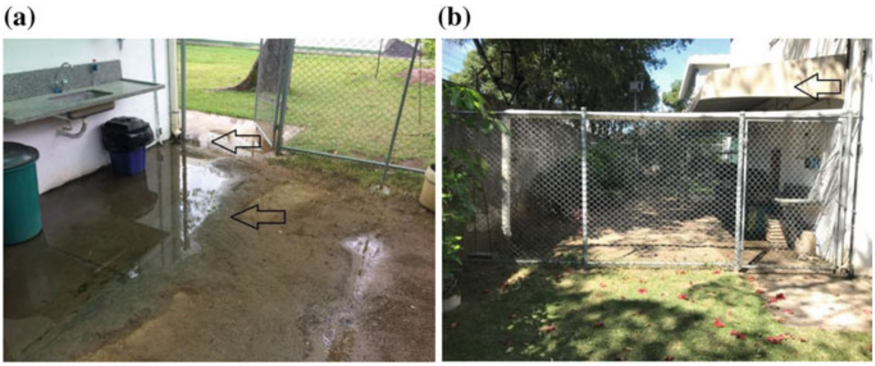

Fig. 1 Original discharge of rainwater drainage from the roof (**a**) and designed and deployed system for diverting and collecting rainwater from the roof (**b**)

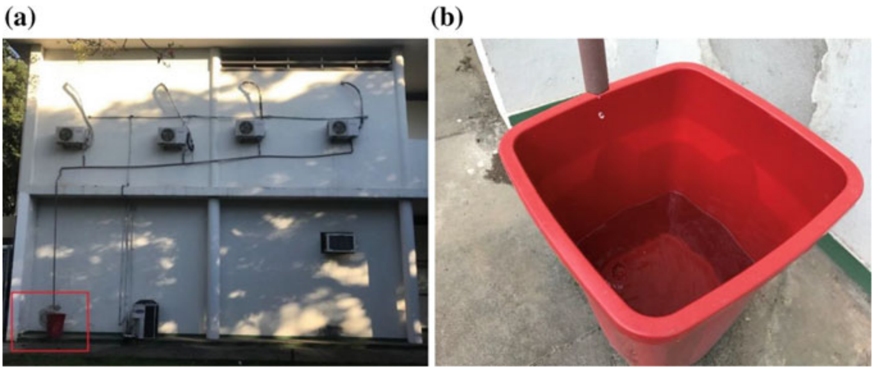

Fig. 2 Haier collection system completed (**a**) and details of the system in operation (**b**)

to be used for the implementation of the complete system were surveyed in the local commerce, and a comparison was made between the cost of the work and the expected time of return for the project.

The period of return of the investment was calculated considering the unpredictability of the rain and frequency of daily use of the air conditioners. For the calculation of the return of the system based on the apparatuses was considered the monthly water generation of the same multiplied by the tariff of the concessionaire. The value found represents the monthly savings, which was deducted from the amount invested, thus obtaining the expected term.

The calculation of the return period of the rainwater system considered that the volume of 15,000.00 L of the reservoir multiplied by 5.61, which is the rate applied by the local Company of Treated Water and Supply, CESAN, for volumes up to 15.00 m^3. Due to the imprecision related to the randomness of the hydrological phenomena, it was considered to calculate the occurrence of 50 mm of rain on the roof monthly, which would represent a value of 16,000.00 L captured by the studied area. Therefore, for academic purposes, the capacity of the reservoir in the calculation of the period of return of the investment was adopted.

5 Results and Discussion

Roof dimensions were obtained using AutoCAD software. Through the pavilion plants, a length of 55.45 m and a width of 9.73 m was found for corrugated tiles, with a slope of 17% and a height of 1.02 m. The rail is 50 cm wide. With the inspection of the roof it was possible to perceive the existence of seven pipes of descent of the rainwater, and among these, only two present the pipe visible and the other five are embedded in the construction. Furthermore, it was found that the roof is divided in half by two concrete obstructions in the larger rails. The visit to the roof also identified a large accumulation of leaves in the gutters. The accumulation of leaves can cause obstruction of the flow section and, if routed to the cistern, directly interfere with the water quality, mainly increasing the content of organic matter and, consequently, resulting in the presence of microorganisms, which may be pathogenic due to the feces of birds and rodents.

There were 38 air conditioners counted, including two types and five brands (Table 1). The split models correspond to 18 devices (47% of the total) while the window models are represented by 20 devices (53% of the total). Among all models observed, only two present different power of 18,000 BTU/h, both models being split of the Carrier brand.

The 38 apparatuses observed in the study were installed in 18 rooms, and the Department of Mathematics was the responsible for six window models of the Springer brand. Of all the rooms classified as office of the Head of Department, it has the largest area and the largest number of people attending. In fact, of all rooms, those that presented constant frequency of use during different days and in different periods of the same day were those of the Head of Department.

Table 1 Number of air conditioners observed by brand and type

Brand	Type	Power (BTU/h)	Quantity
California	Split	18,000	12
Carrier	Split	48,000	2
Gree	Janela	18,000	6
Haier	Split	18,000	4
Springer	Janela	18,000	14

Table 2 Areas, demands and volumes calculated for the day of consumption

Place	Area (m^2)	Demand (l/m^2/day)	Volume (l/day)
Rooms	1,741.08	2	3,482.16
Halls	775.99	2	1,555.98
Gardens	1,342.53	2	2,685.06
Total	3,184.12	–	7,723.20

As indicated by the coordinators, all the devices in the present study have frequent filter cleaning and maintenance, but they have not been able to specify their periodicity. After careful observation of all the appliances, none was found to have an efficient drainage system for the generated water. All appliances have the water thrown directly on the sidewalk located near the pavilions.

According to the survey on water demand, both cleaning and gardening staff reported that the water used comes from the water utility's network (CESAN). For cleaning services, water is used mainly for cleaning the floors of rooms and corridors with daily frequency, while for gardening, it is used for irrigation and maintenance of the grass and trees of the campus with frequency of twice a week or weekly in drier season.

From the areas obtained for rooms, corridors and gardens it was possible to estimate the global volume demanded for the activities for each day of water use, for cleaning or irrigation, being the entire area considered (Table 2).

As the demand of water use was calculated for the day, the monthly frequency of washes (being 20 working days) and irrigation (twice a week) to calculate the monthly cost with treated water should be taken into account (Table 3). It is also important to consider that in the demand for treated water the rate of sewage collected by the concessionaire, equivalent to 80% the cost of treated water, increasing the final value obtained with the demand.

The total area considered for the project was 185.18 m^2. From the equation of the intense rainfall equations, a rainfall of a project with a five-year return period for the municipality of Vitória yields a precipitation of 133.1 mm/h. The design flow rate was calculated as Q = 102.70 L/min.

Considering the air conditioners, measurements were performed between August 2016 and April 2017. From the values obtained, with the measurements for fifteen minutes, Table 4 was elaborated with the means of volume generated and the flow of

Table 3 Monthly cost for use of treated water in environments

Local	Daily demand (L/day)	Daily cost with sewage rate (R$)	Frequency (days)	Monthly demand (L/month)	Total monthly value (R$)
Cleaning					
Rooms	3,482.16	31.08	20	69,643.32	621.72
Halls	1,555.98	13.89	20	31,119.60	277.92
Irrigation					
Gardens	2,685.06	23.98	8	21,480.48	191.81
Total	7,723.20	38.31	–	122,243.40	1,091.45

the apparatus, by model. The flow of Haier appliances was considered to be composed of four appliances, since the collection model was installed so that all were drained to the same outlet. According to observations of the water generation, it was found that the Split models presented higher energy efficiency, consequently the window models produced a larger volume of water. Apparatus, especially the Split, had a large initial production of water due to the high humidity rates in the environments, whose value stabilized over time, since the volume generated in the first minutes was higher than the volume generated in the final minutes. Finally, considering all appliances, in all study rooms, a daily volume of 289.36 L was found.

From the results obtained, Table 4, it was set up as a way of comparison for the analyzed sources and parameters. In addition to the comparison between the sources, an analysis of compliance with CONAMA Resolution 357/2005 was carried out, according to the maximum permitted values (MPV) for waters of class 3. The results of the chemical and microbiological analysis indicate a similarity of values between the sources, allowing the use of both for purpose of cleaning the rooms and corridors, besides watering the gardens, after a simple filtration process that has the purpose of reducing the matter avoid accumulation of solids in the reservoirs.

From the quantitative and qualitative analysis, as well as the location of the air conditioners and the local drainage, it seems more efficient the use of two reservoirs separately for each source of water. For rainwater, with the possibility of supplying a large part of the cleaning demand of the rooms and corridors with each rain for at least two days of use, a water box with a volume of 15,000 L should be adopted, located near Labiotecs and discharge of the roof, reducing costs with new pipes. According to the rainfall characteristics in the municipality and the catchment area, it is predicted that the reservoir has the capacity to be filled in about 84 min of heavy rainfall.

The reservoir intended to store the volume of water generated by the air conditioners has been calculated for the maximum accumulation period of three days if the reserved volume is used for washing and irrigation twice a week. Therefore, its volume was estimated at 851.8 L and adopting a safety factor of 10%, a volume of 934 L is obtained. Commercially, a 1000 L reservoir is indicated as the more appropriate for the project, and the best position for the project will be in the center of

Table 4 Mean values obtained in the laboratory analysis

Parameter	Source	Unity	Value	Maximum	Agree?
Residual chlorine	Air conditioning	Mg/l	Negative	Positive	Yes
	Rain		Negative		Yes
Coliforms	Air conditioning	Absence/presence	Absence	4,000/100 mL	Yes
	Rain		Presence		Yes
Cor aparente	Air conditioning	Hazen unity	0	75	Yes
	Rain		35		Yes
E. coli	Air conditioning	Absence/presence	Absence	Presence	Yes
	Rain		Presence		Yes
pH	Air conditioning	–	7.15	6.0–9.0	Yes
	Rain		6.91		Yes
Sólidos st	Air conditioning	Mg/l	6.67	20	Yes
	Rain		13.3		Yes
Turbidez	Air conditioning	Ntu	0.02	100	Yes
	Rain		5.55		Yes

the garden, and then the setting would allow automation of a supply system and to reduce pipe costs by connecting the appliances, as well as to show to the community the existence of this sustainable water project, and its operation.

It was possible to obtain an approximate cost of the material for the implementation of the complete system, considering the positions of the discharge of rainwater, the air conditioners and the proposed reservoirs. A comparison between the cost to the Institution when using treated water and the amount that can be saved by adopting on-site water systems has been traced. The reservoirs, mainly the one destined to the storage of rainwater of the roof, represent great part of the value to be invested. Then, the PVC pipes used to conduct the collected water volume have significant values. The total value for the deployment of the two storage systems was estimated at R$ 5.890,00 ($ 1,864.81), and this cost may be more expensive or not depending on the price of the materials in the period of purchase. Of the amount presented, R$ 5.200,00 ($ 1,646.35) are destined for the rainwater system of the roof and R$ 690.00 are destined to capture the water generated by air conditioners.

The period of investment's return found for air conditioners was 24.04 months or approximately two years. For the rainwater harvesting system, the return period was estimated at 61.8 months or 5.15 years. However, two points stand out. From the installation of the two systems, the one destined to the air conditioners would be paid in 24.04 months. Taking into account the benefit generated by the other system at that time, an economy of R$ 2,02297 ($ 640.48) would have occurred, and from that moment the economy of the two systems could be added to reduce the rest of the investment. In this case, with a total savings of R$ 112.85 ($ 35.73), per month, the remaining R$ 3,177.03 ($ 1,005.87), has a return period of 28.15 months or 2.34 years. It is estimated, therefore, a total return period of the two systems of 52.19 months or 4.35 years.

6 Conclusions

The study sought to show the feasibility of installing a system for collecting and using rainwater drained from roofs and water generated by air conditioning devices, together with the characterization of the water quality. Samples were collected between 2016 and 2017 for water volume measurements and chemical analysis for water quality characterization. IDF equation for Vitória city was applied to evaluate the rainfall intensity and to determine the project discharge. This also allow the evaluation of the raised demand for the use of this volume collected around the Laboratory.

The air conditioners studied generate a total of 289 L per day, which represents 5787 L in a month, while the estimated rainwater flow rate on the catchment surface is 102.70 L per minute. The rainfall water and that generated by air conditioners were characterized by a good quality, and the parameters analyzed were in accordance with the National Technical Standard of water quality.

The sustainable focusing lightning on computing all air conditioners apparatus installed and operating in the Federal Institute of Espírito Santo—Campus Vitória, and the considerable area of catching of rainfall which can fill, not only, the demand for cleaning and garden irrigation, but also discharges of sanitary vessels further reducing the consumption of drinking water, have an exciting demonstration of how some simple actions can *reinforce* sustainable actions possibilities at different scales.

The projected funding system has an expected period of investment return of 52.19 months or 4.35 years. It is worth mentioning that this work is the first stage of more in-depth studies, aiming at the implantation of permanent reservoirs at the Federal Institute of Espírito Santo—Campus Vitória, not only to reduce the consumption of drinking water, but also to foster thought demonstrating the possibility of capturing, storing and using alternative sources.

In this sense, it is worth mentioning that several employees and students praised the implementation of the Haier appliance collection system, since there was no previous study on the campus about the water expelled by the appliances and contributed with ideas and suggestions on the expansion of the study in the future.

Therefore, this is a study with great applicability for the future of the Institution, whose thinking must be focused on the adoption of sustainable policies and cost reduction, so that it is feasible to use alternative sources of water for less noble demands.

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Assessment of Sustainability Elements in Forestry Department of Peninsular Malaysia by Using Universiti Sains Malaysia's Sustainability Assessment Methodology (SAM)

Marlinah Muslim, Siti Fairuz Mohd Radzi and Mohd Sayuti Hassan

Abstract The Sustainability Assessment Methodology (SAM) has been developed by the Centre for Global Sustainability Studies (CGSS) of Universiti Sains Malaysia (USM). SAM uses the Sustainability/Sustainable Development 'criteria and standards' based approach for this purpose as review in this paper. The standard validity of this approach is attested by its dependence on the major outcome documents published by the United Nations and other relevant national report for Millenium Development Goals (MDG) agenda and WEHAB Framework. In this paper, SAM is used to assess the sustainability content of the activities of the Forestry Department of Peninsular Malaysia (JPSM) by using 6 years of annual reports of JPSM as the source of input. The main reason as to why authors did not use 2016 and later annual report is because of the authors intend to compare the result with MDG indicators. The authors realise that there are specific assessment that has been used by the JPSM to evaluate the peninsular forest management, however, this study does not intend to interfere those certification and assessment. The only aim of this study is to gauge their overall confinement to the global sustainability thinking and priorities.

Keywords Sustainability · Sustainable development · Forestry assessment · SAM · JPSM · MDG · WEHAB

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1 Introduction

Forestry Department Peninsular Malaysia (JPSM) is a department under the Ministry of Natural Resources and Environment of Malaysia which is responsible for maintaining and managing forests in peninsular Malaysia. Under the JPSM there are many units that have been set up for more systematic management as well as management under the state for each state in Peninsular Malaysia. Furthermore, JPSM also has its own forest assessment system such as ITTO Criteria and Indicators for Sustainable Forest Management, MC and I 2001 and MC and I (Natural Forest). In this paper, SAM is used to assess the *sustainability content* of the activities of the Forestry Department of Peninsular Malaysia (JPSM) through 6 years of annual reports. The annual reports are 2009, 2010, 2011, 2013, 2014 and 2015. The reason why authors did not test 2016 and later reports because of the authors want to see how results get along with the Millenium Development Goals which ended in 2015 and replaced by Sustainable Development Goals which came to effective in 2016. This study is intended to gauge their overall confinement and commitment to the global sustainability thinking and priorities followed the Millenium Development Goals (MDGs) agenda and WEHAB Framework that focus on Water, Energy, Health, Agriculture and Biodiversity. Authors do not have any other intention to replace or to dispute the current Criteria and Indicators for their Sustainable Forest Management.

2 Literature Review

2.1 Sustainability/Sustainable Development Assessment in Forest Management

According to Ness et al. (2007) "The sustainability assessment is used to give decision-makers with an evaluation of global to local integrated nature–society systems in short and long term perspectives to assist them in actions of should or should not be taken in an attempt to make society sustainable". All sustainability assessment require all users of these assessments to have the knowledge and understanding of sustainability principles and concepts (Suzyrman et al. 2014).

Stork et al. (1997) mentioned that criteria and indicators (C&I) need to be applied at the forest management unit level and those for biodiversity are just one part of a package that includes socio-economic and other categories. Biodiversity is an extraordinarily broad concept for huge diversity of life in tropical forests. It is impossible to make rapid direct assessments of biodiversity in forests and also it is likely that there will be limited skilled of human resources and time for biodiversity assessment, so it is important that designing tools that do not require expert application and interpretation (Stork et al. 1997).

Holvoet and Muys (2004) stated that the number of initiatives aimed at the evaluation of Sustainable Forest Management has risen greatly since the UNCED Conference in Rio de Janeiro in 1992. Many countries and regions standards with Principles, Criteria, and Indicators of Sustainable Forest Management (SFM) have been developed. In most cases, the development is based on framework of an intergovernmental or international initiative (Holvoet and Muys 2004).

2.2 *Sustainability Assessment by Forestry Department of Peninsular Malaysia (JPSM)*

The formulation of criteria and indicators as a tool to assess sustainable forest management in Peninsular Malaysia started in 1994 based on the International Tropical Timber Organisation (ITTO) Criteria and Indicators for Sustainable Forest Management published in 1992 by JPSM initiatives. In 1996 to 1999, as a cooperation programme under the Malaysia, the Netherlands Joint Working Group on Forestry, a pilot study on timber certification was tested in Pahang, Selangor and Terengganu and also developed several factors to adopt such as ITTO Criteria, Indicators for Sustainable Management of Natural Tropical Forests and to formulate a national standard for forest management certification. As the result, a document entitled Malaysian Criteria, Indicators, Activities and Standards of Performance (MC&I) for Forest Management Certification (Forest Management Unit Level), Peninsular Malaysia (Malaysia-The Netherlands Ad Hoc Working Group) dated 23 December 1999. The document is also commonly known as MC&I 2001 (JPSM 2016).

Through JPSM, Malaysia has used the ITTO and Criteria and Indicator (C&I) as a framework for their forest certification standards (Rametsteiner and Simula 2003). Malaysia also undertook a review of its policy framework resulting in amendments to the National Forestry Act in 1993 (Ali 1998) and applied separate sectoral policies such as the National Policy on Biodiversity (MOSTE 1998) and National Policy on the Environment (MOSTE 2002). A comprehensive study of the nation's green policy, the National Conservation Strategy, was completed in 1993 by WWFM for the Economic Planning Unit (EPU), Prime Minister's Department (EPU Malaysia 1993).

Currently, JPSM uses Malaysian Criteria and Indicators for Forest Management Certification, also known as MC&I 2002 for their Forest Assessment. MC&I 2002 is a result from the updated MC&I 2001. MC&I Standard 2002 has been updated in line with the outcome of its feedback and experience in the field and has been replaced with the MC&I (Natural Forest) under the Program for The Endorsement of Forest Certification Schemes (PEFC) through the Malaysian Timber Certification Scheme (MTCS) and effective from January 2013 (JPSM 2016).

2.3 Universiti Sains Malaysia's Sustainability Assessment Methodology (SAM)

The Sustainability Assessment Methodology (SAM) is a computerised tool to measure sustainability/sustainable development which has been developed by the Centre for Global Sustainability Studies (CGSS) of Universiti Sains Malaysia (USM) in 2011 (Suzyrman et al. 2014). Initially, SAM was intended to monitor the sustainability *content* of courses, research projects and administrative documentation used by the university. SAM uses a 'criteria and standards' based approach for this purpose. The criteria involve a broad grouping of 12 items based on WEHAB Framework in addition of Sustainability Education and several cross sectoral areas as shown in Fig. 1. The *standards* are defined by 24 sets of descriptive indicators. SAM has since been computerized with an input (any form of written documentation such as course synopsis, project report, policy documentation) process (considers the 12 criteria and checks them against a detailed set of words and bi-words derived from the 24 set of indicators) and output (display in different forms, see Fig. 1). The validity of this approach is attested by its dependence on the major outcome documents published by the United Nations (UN) such as the Stockholm Declaration, the Brundtland Report, Agenda 21, the Earth Charter, the Johannesburg Plan of Implementation, The Future We Want and other revelent national report (Suzyrman et al. 2014). All of those UN publication is for MDG agenda and align with WEHAB Framework. As the result, CGSS has been able to publish the methodology in international journals, books and had also won two national awards on a competitive basis.

There are three steps in SAM: Screening, Identification, and Classification. In screening, the subject will be assessed for three types of pillars; Economy, People and Environment. Then, in identification process, the subject will analysed using indicators in SAM and at the last step subject can be classified into sustainability categories; Low Sustainability, Medium Sustainability or High Sustainability (Koshy et al. 2013; Suzyrman et al. 2014).

3 Methodology and Data

3.1 SAM Processing Approach

SAM is a computer based methodology application that follows a three-stage "Input, Process, Output" approach in computer science term or known as *Screening, Identification*, and *Classification* in SAM language. The input uses Portable Document (PDF) Format report and then the Input will be analysed in the Processing step. In the final Output step, the results are displayed automatically in a variety of forms such as pie chart, histogram, word clouds, sustainability percentage, bar chart, traffic light plots, and spider chart. For the purpose of this assessment, the histogram and table were chosen to display result. Figure 2 is the SAM processing steps.

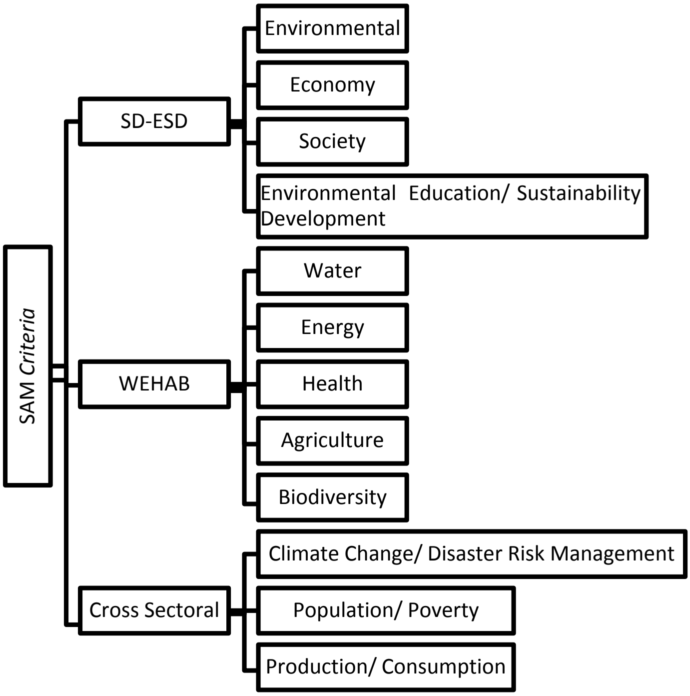

Fig. 1 *Criteria* in SAM analysis

3.2 JPSM Annual Report as Input Data to Assess

The 6 years (2009–2015) of annual report in PDF format of JPSM used as the input data. Each annual report contains varieties of pages, sentences and elements which needed to analyse by SAM. The following reports by JPSM were used in this assessment;

i. 2009 JPSM Annual Report (204 pages)
ii. 2010 JPSM Annual Report (195 pages)
iii. 2011 JPSM Annual Report (196 Pages)
iv. 2013 JPSM Annual Report (209 Pages)
v. 2014 JPSM Annual Report (184 Pages)
vi. 2015 JPSM Annual Report (184 Pages).

The 2012 JPSM annual report could not be analysed due to documentation error in SAM application because most of the content in the year 2012 report is in image format. At the moment, SAM does not have the features that could read JPG format or any other image format.

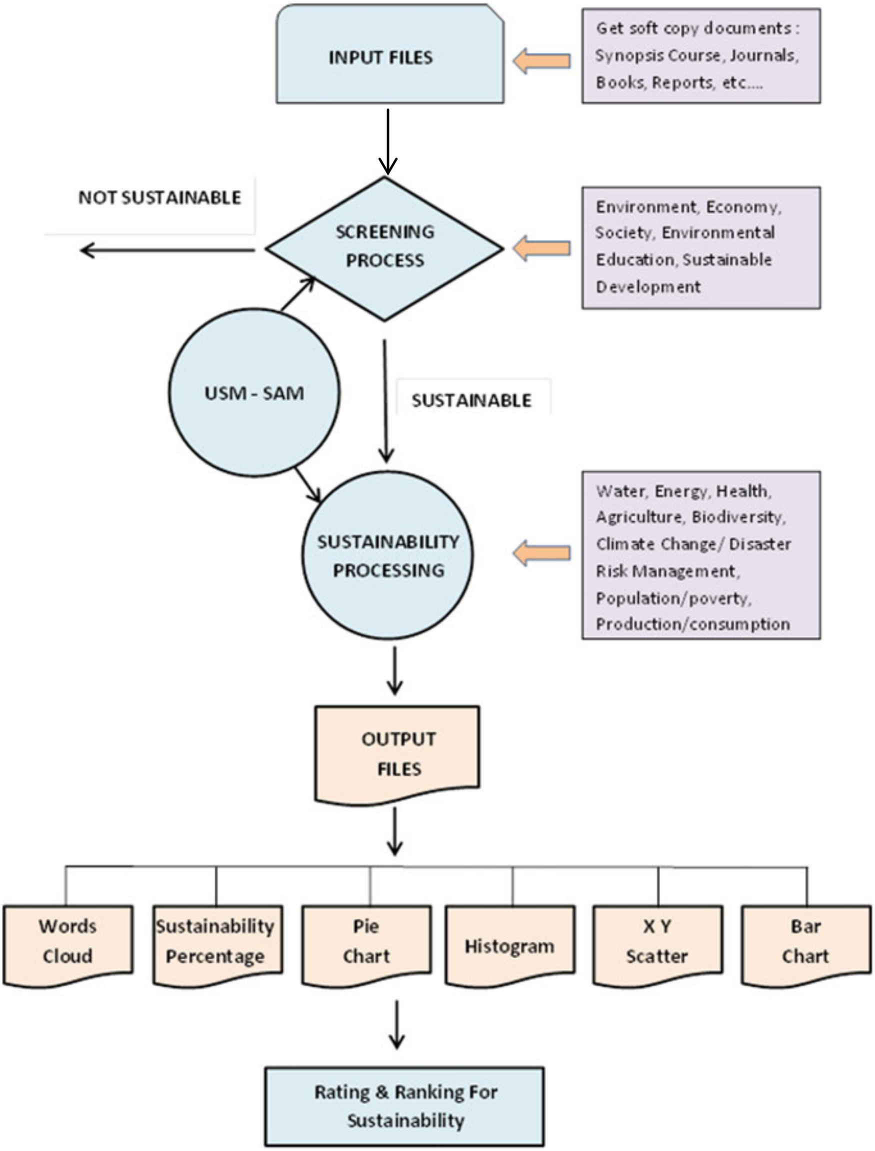

Fig. 2 SAM processing steps

Table 1 Overall JPSM sustainability result by SAM

Year	JPSM sustainability result in SAM (%)
2009	14.39
2010	16.42
2011	16.99
2013	17.65
2014	19.27
2015	16.53

4 Result and Discussion

SAM has been applied to the entire JPSM softcopy of Annual Report of the year 2009, 2010, 2011, 2012, 2013, 2014 and 2015. SAM = assessed all the report successfully except for the year 2012 due to the error in the report content.

As for the result for 2009 Report, JPSM scored 14.39% of overall sustainability assessment and it is in *Low Sustainability* Classification. Result is generated in SAM as shown in Fig. 3a–c in which the figures show the result for every *criterion*. All of the six years result are shown in Table 1. SAM classified the overall JPSM sustainability as *Low Sustainability classification* for the result lower than 30%, *Medium Sustainability* and *Higher Sustainability*, for the result more than 30%.

Figure 4 showed that the sustainability pattern is in good development from 2009 to 2014 for Forestry Department of Peninsular Malaysia. The percentage increased from 2009 to 2014 with 14.39% in 2009 to 19.27% in 2014, however, the percentage has a slight decrease to 16.53% in 2015.

4.1 SD-ESD, WEHAB, Cross Sectoral Elements Analysis in JPSM

To align with Millenium Development Goals and WEHAB Framework, SAM has been designed to assess the performance of Sustainable Development and Education for Sustainable Development (SD-ESD), Water, Energy, Health, Agriculture and Biodiversity (WEHAB) and Cross Sectoral areas in Population and Poverty, Production and Consumption, and Disaster Risk Management for Sustainable Development. The graph of the six years result for SD-ESD, WEHAB and Cross Sectoral categories are shown in Fig. 5.

Eventhough all of categories were in *Low Sustainability* classification based on SAM measurement, it clearly shown that JPSM have their own initiative in SD-ESD category which include the Environment, Economy, Society and Environment Education/Sustainable Development elements. It is relevant to JPSM itself where JPSM has been working a lot on environmental-related areas. Overall, based on the

(a)

Your Document Title: JPSM2009

CRITERIA TYPE	TOTAL OF SUSTAINABILTY PERCENTAGE (%)
SD - ESD	19.62
WEHAB	12.83
CROSS SECTORIAL (+3)	10.02

View Details Result (Table)

*The above table shows the total words that matches with the criteria which are evaluated from three categories and was totaled up as a percentage.

The three categories are:

- SD-ESD: Sustainability Education - Education for Sustainability Development
- WEHAB : Water, Energy, Health, Agriculture, Biodiversity
- Cross Sectorial +3: Climate Change, Production Consumption and Population Poverty

Total Average of Sustainability = 14.39%

*Total Average of Sustainability = Total average from all three categories based on their criterias.

(b)

Your Document Title:JPSM2009

Excel Display

CRITERIA TYPE	TOTAL OF SUSTAINABILTY PERCENTAGE (
ENVIRONMENT	31.25
ECONOMY	25.59
SOCIETY	15.75
ENVIRONMENTAL EDUCATION / SUSTAINABILITY DEVELOPMENT	5.88
WATER	10.00
ENERGY	5.27
HEALTH	2.63
AGRICULTURE	21.25
BIODIVERSITY	25.00
CLIMATE CHANGE /DISASTER RISK MANAGEMENT	8.51
POPULATION / POVERTY	16.79
PRODUCTION / CONSUMPTION	4.76
RESULT BY CATEGORY	
SD - ESD	19.62
WEHAB	12.83
CROSS SECTORIAL (+3)	10.02
TOTAL AVERAGE OF SUSTAINABILITY	
Total Average	14.39

(c)

Fig. 3 **a** Total average of sustainability for year 2009 and the categories details. **b** The sustainability percentage for sustainability criteria, categories and total average percentage of sustainability for year 2009. **c** The three category sustainability percentage for year 2009

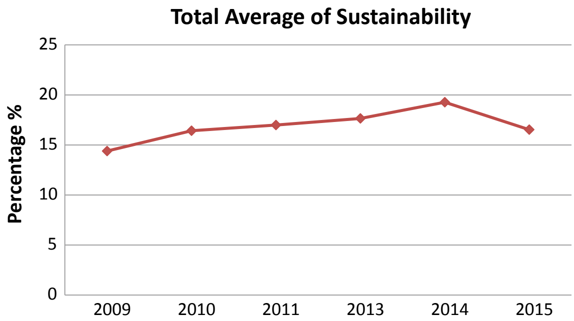

Fig. 4 Pattern of the overall sustainability result for JPSM

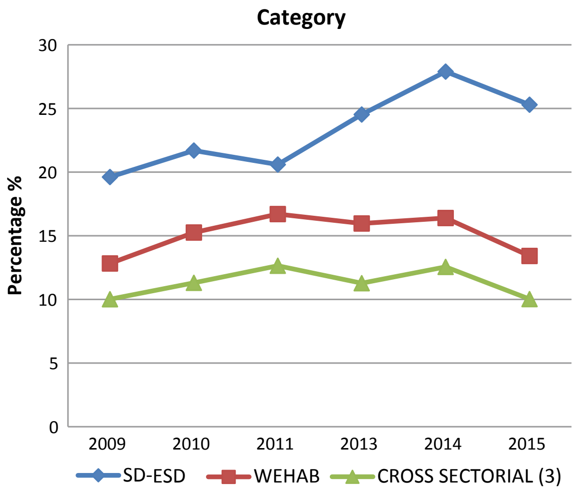

Fig. 5 SD-ESD, WEHAB, cross sectoral elements pattern

result, it can be concluded that JPSM involved in global sustainability thinking and priorities.

4.2 Criteria Analysis in JPSM

The graph below showed the criteria analysis in SAM for JPSM Reports. The graph clearly showed that 2011 to 2014 give JPSM a very positive ascending result in Sustainability but there must be a reliable reason why the result drop in 2015. It is quite questionable for the drop result since Sustainable Development Goals (SDGs) has taken effect in 2016. JPSM focused efforts towards environmental management and it is clearly translated in its report. The result shown in Table 2 and Fig. 6 where *Environment* Criteria is the best result compared to other criteria. Environment criteria maintained in *Medium Sustainability* Classification (above 30%) and never

Table 2 Sustainability criteria analysis in JPSM

Criteria	Year					
	2009 (%)	2010 (%)	2011 (%)	2013 (%)	2014 (%)	2015 (%)
Environment	31.25	35.42	33.34	37.50	43.75	39.98
Economy	25.59	25.59	25.59	30.20	31.87	30.20
Society	15.75	15.75	17.60	20.37	25.93	22.22
Environment education/sustainable development	5.88	10.05	5.88	10.05	10.05	8.83
Water	10.00	12.50	10.00	10.00	19.17	10.00
Energy	5.27	5.27	7.89	5.27	7.90	5.27
Health	2.63	2.63	2.63	2.63	2.63	2.63
Agriculture	21.25	23.75	23.75	26.65	23.75	20.63
Biodiversity	25.00	32.15	39.29	35.71	28.57	28.57
Climate change/DRM	8.51	8.52	6.34	6.34	10.60	8.43
Population/poverty	16.79	13.39	21.84	20.23	15.06	16.79
Production/consumption	4.76	12.03	9.76	7.26	12.03	4.88

declined to *Low Sustainability* classification. The detail of other result of criteria is shown in Table 2 and Fig. 6.

5 Conclusion

Based on the result presented in this article, it can be concluded that JPSM is still aligned with the global sustainability agenda and their initiative in various criteria for sustainability has been proven by the results generated by SAM. SAM also has helped JPSM in identifying its main priority areas such as in Environment where JPSM has received the highest result for the said criterion.

The opportunities for SAM innovation in the sustainability field have been identified as a useful tool for sustainability assessment performance and it can be developed in the future to align with the global 2030 Agenda or Sustainable Development Goals (SDGs). Sustainability concepts that have emerged over the recent decades which are related to sustainability education, economy, environment, water, energy, health, agriculture, biodiversity, climate change, disaster risk management, population, poverty, production and consumption can be examined by using SAM application. SAM strongly follows the MDGs agenda and WEHAB Framework, however, each criterion in SAM could be developed to follow the criteria in SDGs to assist universities, organizations, or individuals in assessing the level of SDGs element for their initiatives which are translated into written reports.

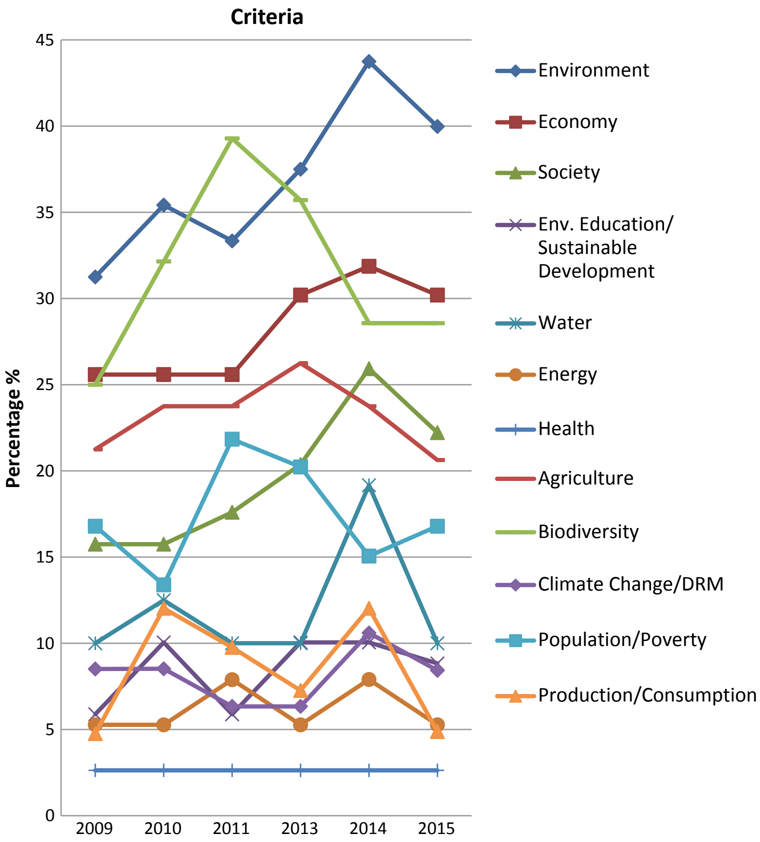

Fig. 6 Sustainability criteria in JPSM using SAM

The assessment of sustainability elements in JPSM by using SAM hopefully would help JPSM in reorienting their management to follow the global sustainability agenda. Lastly, it is hoped that JPSM would be fully prepared to go in line with the SDGs and would provide positive result for SDGs at the end of 2030.

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Pachamama—La Universidad del 'Buen Vivir': A First Nations Sustainability University in Latin America

Susanne Maria Weber and Maria Alejandra Tascón

Abstract The alternative development paradigm, 'Buen Vivir', positions community perspectives as the core of its vision. As an alternative to an (anthropocentric) vision it offers an inclusive socio-ecological idea, which regards 'Mother Earth' (called Pachamama) as a being with its own rights. This alternative vision puts ecological, socio-cultural, spiritual and political dimensions of an alternative path of development into play and suggests a new ethics of development. Based on the concept of 'Buen Vivir', indigenous educational concepts of Higher Education are developing and emerging, applying project-based learning methods. Topics for a sustainability university relate to the fields of water resources, coffee, sustainable nutrition, arts etc., as well as collective decision making, education, etc. In this vision, global solidarity for sustainable development supports ecosystem development and sustainable development. It develops studies in solidarity economy, water sustainability, Fair Trade and sustainable education. The paper begins with critiques and the global search for alternatives (1), and shifts to introduce the 'Buen Vivir' approach (2). In a third chapter, the state of the art of alternative and indigenous universities in Latin America will be addressed (3). In the fourth and final chapter, elements of the developmental vision of an intercultural and transcontinental Fair Trade University—the Universidad "Pachamama" will be presented (4).

Keywords Buen Vivir · Higher Education · Education for Sustainable Development · Fair Trade University · First Nation University

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1 Global Critiques—Global Search for Alternatives in Paradigm Development

Present debates on alternative universities emerge from different developmental models. Western approaches criticize acceleration (Rosa 2013) and from there formulate alternatives of resonance and wellbeing (Rosa et al. 2014), Far Eastern alternative developmental models center around spirituality and collective wellbeing, such as the 'Gross National Happiness' model of Bhutan. The Bhutanese government has declared happiness as the leading vision of their national development initiatives and political approaches (Weber 2015).

All those debates can be used together to challenge the given paradigms of development. These voices claim a shift towards inclusion, in the sense of social, ecological and economical, as well as cultural sustainability as a new paradigmatic shift in our present age. Organizing inclusion and sustainability in the given context becomes increasingly relevant for universities, too. In order to lead into sustainability and social innovation strategies, these approaches tend to involve interorganizational cooperation, multi-stakeholder processes and multi-layered governance of educational and regional or global actors.

While western concepts of inclusion and diversity relate to deceleration, wellbeing and social security, Latin American cosmology includes spiritual dimensions, which become relevant as a topic and as a practice for organizing and realizing Higher Education. In different approaches, we find models connected to the movement of the "Commons" (Helfrich et al. 2012), which practices inclusiveness and collective responsibility (Ostrom 1990). Debates on "lived sufficiency" in its elements of deceleration, societal and collective use of goods, of less and conscious consumption come into view, when adopting the concept of 'Buen Vivir' as a paradigm and as an orienting vision for alternative universities.

2 'BUEN VIVIR'—The Latin American Alternative Paradigm Questioning 'Development'

Sumak kawsay (kechwa from Peru or kichwa in Ecuador), *Suma qamaña* (aymara from Bolivia), *ñande reko* (guaraní from Paraguay) are the most well-known indigenous concepts of 'Wellbeing', or 'Buen Vivir' today. This concept was developed by CAOI (Coordinación Andina de Organización Indígenas), the roof organization of indigenous organizations of the Andes. In the beginning of the 20th century it was formulated in order to define a collective indigenous concept of Wellbeing (Huanacuni 2010).

This paradigm of life refers to ancient traditions and styles of life, which are observed in all indigenous communities within Latin America. The *Mapuche* (Chile and Argentine), the *Kolla* (Argentina) and different nations of the Amazons joined, to form a consortium indigenous organizations of the Amazonian COICA

(Coordinadora de las Organizaciones Indígenas de la Cuenca Amazónica). COICA considers the principle and vision of ‘Buen Vivir’ as a foundation of their specific cosmology and hereby use different terms (like for example “Maloka”) (Huanacuni 2010).

‘Buen Vivir’ goes beyond being a concept; it represents an ethical paradigm, in which nature is understood as belonging to the indigenous people and their respective nations. Following Estermann (1999), ‘Sumak kawsay’ can be understood as a ‘cosmological ethic’ searching for harmony and conviviality between human beings and nature. This approach is not about defining a complete life, or an ‘art of living’ (García 2004). The relationship between humans and nature is not understood in the sense of an ontological rupture, where the wellbeing of the modern human being is in the center of analysis and reflection. The core of these concepts is the preservation of the cosmic order and life giving relations and relationships. The ‘collective’ refers to everything existing. Harmony can only be created in a holistic and integrational perspective on everything and every existing being. Estermann (1999) here refers to co- and interdependency.

Thanks to indigenous organizations, to social movements and the institutions of civil society, the term ‘sumac kawsay’ or ‘Buen Vivir’ (León 2008a) was legitimized through legislation and a constitutional assembly. Acosta and Martínez (2009) discuss it in the context of developmental strategies; Welsh (2009) sees it as a political paradigm, as an ethical discourse and as a term of gender (León 2008b). Like this, ‘Buen Vivir’ holistically connects different dimensions and fields of life. This brings ecological, socio-cultural, spiritual and political dimensions of an alternative developmental path into play and suggests a new developmental ethics (Cortez and Wagner 2010).

The utilitarian relation of humans towards nature, the monocultural-colonial orientational pattern of state and the asymmetric structuring of society are deeply criticized here. Developmental approaches founded in ‘sumak kawsay’ are grounded in thoughts of *plurinational* (recognizing differences) states and an *intercultural* (collective commonalities) society. Within the framework of this paradigm, *plurinationality* and *interculturality* (Walsh 2009) can be understood as complementary political principles, restructuring and decolonizing the postcolonial state at a local level (Cortez and Wagner 2010). For the sociologist and political scientist Quijano (2000), the process of decolonization has to play a crucial role in the creation of a sustainable society: Behind the ‘coloniality of power’ is not only a structural racist criterion, but a will to dominate nature.

In order to operationalize the concept, the economist and indigenous activist Germán Muruchi presents the four principles of ‘Buen Vivir’. *Reciprocity* (1); every being and life exists within mutual reciprocity. Any form of life does not exist in an isolated way and will not be in opposition to others. *Plurality* (2); life creates diversity and variety as an individual process of living. *Cyclic movement of life* (3); time is not linear and moves in *spirals*, inverting. *Future implies a principle of return Equilibrium* (4); Health is not regarded as absence of illness, but as collective systemic state of perfection (Muruchi Poma 2017).

Finally it has to be said, that the basic principle of 'Buen Vivir' connects to a variety of global approaches. Arne Naess (1912–2009), for example, is one of the most important representatives of 'Deep Ecology', or Aldo Leopold (1887–1948), who had mid of the twentieth century with his ethics of sustainability strong influence, presented similar thoughts. Additionally, eco-feminist approaches connect to 'Buen Vivir', for example Vandana Shiva's approach, which can be understood as a postcolonial political concept. 'Sumak Kawsay' is to be regarded as a societal alternative, transcending the world of indigenous people and of intercultural relevance (Cortez and Wagner 2010).

3 Alternative and Indigenous Universities of Latin America—State of the Art

Within European debates sustainability networks like 'COPERNICUS' (network for cooperation of European universities for European knowledge exchange and exchange of experiences in sustainable development (in 1993)) or the 'Global Higher Education Partnership for Sustainability' (GHEPS) have been established (in 2001). Unfortunately, these developments and debates lack sufficient connections to the Latin American sustainability discourse.

In the late 1960s, within the South American educational debates, consciousness has been rising in relevance to Higher Education, especially in the field of sustainability. Some universities have been involved since the 1990s in sustainability initiatives (ALBA 2006). Since 1992, from the Earth Summit, many initiatives have emerged. The educational scientist, Germán Vargas Callejas, in his article "Vision and integration of the environmental perspective of the Indigenous University of Bolivia—UNIBOL" (Vargas Callejas 2014) presents, how in Bolivian Universities a sustainability concept has been implemented, which refers to three axes; knowledge production, consciousness rising and sensitizing within the Higher Education community, and sustainability and environmental planning and administration. These axes cover the inclusion of sustainability issues in Academia and its surrounding communities while fostering participation within them. Organizational and administrative initiatives are deemed necessary to Vargas (2014) in order to support usage of responsible natural resources as well as undertaking risk management within the context of Higher Education.

Within the ALBA Summit (Bolivarian Alliance of the American people, 2006) a multilateral Trade Treaty was drafted to support the fostering and consolidation of academic engagement as a guiding principle of the beginning of sustainable development of Higher Education. These requests for a new conceptualization of tertiary education are grounded within a project based approach of design oriented teaching and learning as well as research. Here, participatory and design oriented research as well as transformative education can be supported, like academic councils in Europe, ask for, too (WBGU 2011).

An essential approach of Latin American Higher Education sustainability strategies is to request inclusion, the empowerment of indigenous people and cultural as well as political intercultural justice. Mato (2011) in his article "Indigenous universities in Latin America: Successes, problems and challenges" shows, how the integration of knowledge, languages, modalities of learning and the cosmogony of indigenous people contributes to the system of Higher Education through cultural diversity and opening a dialogue of ethical interculturality.

In regards to cultural diversity and interculturality in Higher Education in Latin America, UNESCO together with the International Institute for Higher Education in Latin America and the Caribe IESALC (Instituto Internacional de la UNESCO para la Educación Superior en América Latina y el Caribe) declared in 2008 to support initiatives of Higher Education in, with, and for indigenous people. The living power of spirituality of indigenous people is meant to broaden the horizon of educational processes and to unfold new possibilities in order to create a harmonic balance between human beings within a country and a territory (UNESCO 2008: 39).

Within the last years, several indigenous universities have arisen. In 2005, the developmental fund of indigenous people of Latin America and the Caribbean founded a first indigenous intercultural university. The UII (Universidad Indigena Intercultural) acted as a network union of and for indigenous universities. Until today, UII involves in total 26 educational centers (Centros Academicos Asociados). Within this plural institutional setting we find conventional public, private, as well as intercultural and indigenous universities, study centers as well as research institutions, which are experienced in the development of educational programs for and with indigenous people. Represented in the network are the following 12 countries: Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, Spain, Guatemala, Mexico, Nicaragua and Venezuela (Cunningham and Nucinkis 2010).

Taking a closer look into the Higher Education programs and courses developed, we can find programs starting with a three month program up to a two years degree. The thematic fields covered relate to:

- Multilingual intercultural education
- Intercultural health
- Indigenous rights
- Governance, indigenous people, human rights and international cooperation
- Development in community strengthening identity for 'Buen Vivir'
- Linguistic and cultural empowerment
- Governance and public administration from an indigenous perspective
- Empowerment of indigenous women in order to take leadership in their communities.

According to the above mentioned, best practice report on indigenous knowledge and Intercultural Indigenous Universities ("Buenas Prácticas Sabidurías y conocimientos indígenas en la Universidad Indígena Intercultural - La Cátedra Indígena Itinerante"), the German National Institute for International Cooperation (GIZ) has accepted the rights and the potential of indigenous people to supports their participation at different levels (Cunningham and Nucinkis 2010). At an international level, the consciousness has grown, that the active participation of indigenous people is part of basic human rights and is crucial in order to support a global society of social coherence. A peaceful solution for growing conflicts on natural resources and their distribution can only be found in egalitarian intercultural approaches, as fostering sustainable development and the millennium goals requires collaboration and cooperation.

Even if, in fact, positive developments are to be found here, so far there is no intercultural and transcontinental institution which follows the specific goal to support the connection between sustainable development, Education for Sustainable Development and Fair Trade. This is why globally interconnected learning formats can be a source to build an indigenous sustainability university based on the 'Buen Vivir' model. Indigenous and European perspectives can be an egalitarian dialogue for design-oriented research and training in the field of Education for Sustainable Development.

4 Envisioning Universidad 'Pachamama': An Intercultural Transcontinental Fair Trade University

The initiative of the indigenous educational organization IDEBIC in Colombia suggests establishing an international and intercultural cooperation, in order to design and develop an alternative indigenous university of sustainability. In a reservation zone in the province of Florida of Colombia, indigenous communities of the 'Nasa' support the concept of 'Buen Vivir' by undertaking a democratic life, an indigenous educational concept and form of schooling, which after 18 years of fighting for national acceptance now has won national accreditation. The approach of project-based learning is suggested for the next step of an indigenous sustainability university, as well. It reflects on the dimensions of 'Buen Vivir' and the potentials within an alternative university for sustainability for first nation people in Latin America.

4.1 A Vision of Project-Based Transnational and Intercultural Learning

The community wishes to create an educational system to fit to ecological, indigenous criteria. They support the idea of conceptualizing an alternative intercultural Higher Education, which might be valid not only for the community, but for the whole continent and its' first nation people assembly as well as for the global earth community, too.

Based on the indigenous logic of 'Ayni', Collective Decision Making, project based and problem based learning as well as life relevance of education, etc. are core elements to be established. As this initiative already realizes project based learning in the fields of water resources, coffee, sustainable nutrition, arts etc., this educational practice, already implemented at the school level, in fact can lead into a sustainability university.

In all fields of Higher Education knowledge acquisition, even in classical material like mathematics, physics, biology, etc., learning and developmental projects connect to ecological thinking and to sustainability approaches. Agricultural projects work with own seed banks, relating to the philosophy of biodiversity. As arts and indigenous cosmology are part of the curriculum, as well as the conservation of first nation languages (Embera Badea & Nasa Yuwe), the loss of cultural heritage especially of younger generations is to be challenged and fought.

These already practiced approaches of a project-based learning is regarded as helpful for a future oriented practice in and of Higher Education. Therefore, the educational network wishes to model an educational practice, which can be relevant, for the Western world, too. The project and problem-based learning relates to approaches known in the field of reform pedagogy and newer approaches in the field of service learning, discussed in international educational and sustainability related debates (Bastenhorst 2005; Singer-Brodowski 2016).

Inclusive futures are to be addressed as organizing processes of communication and coordination between individuals, groups, organizations and networks. They connect to Social and Solidarity Economy, connect to organizations, which "prioritize social and often environmental considerations over private economic interests and profit orientation; involve forms of management or governance which are more horizontal and democratic; and are often linked to forms of collective action and active citizenship" (UNRISD 2016:17). Oriented towards entering life-centered norms and values into the economic sphere, theoretical concepts and empirical approaches as well as best practice models of searches are needed.

In the last years, approaches of sustainable development and Education for Sustainable Development have been developed and driven forward (Michelsen 2000; Käufer and Scharmer 2000; Cortese 2003; de Haan 2008; Barnett 2012; Leal Filho et al. 2016). They offer new opportunities for Higher Education in an international space.

New approaches of eco-social development address the vision and micro utopian practices of interlinking knowledge creation, community-based social and solidarity economy and regional eco-system-innovation. In this sense, a university involving Social and Solidarity Economy connects to a form of economy, which aims to achieve objectives other than only monetary profit. It serves the needs and opportunities of life-worlds and relates to community resilience. It connects to voluntary association, cooperation, democratic governance and self-organization. Its extended life-world-logic of action follow specific needs, citizens' engagement and people's life as well as common concerns.

4.2 Connecting Sustainable Agriculture with Social Development

As the prototype of an ecological university aims to contribute to global solidarity for sustainable development, to ecosystem development and to sustainable development, it is planned to develop studies in solidary economy, sustainable water use, Fair Trade and sustainable education. As a Higher Education model it connects to debates on system innovations and solidary economy.

Social and Solidarity Economy conceptually belongs to the framework of 'diverse economies'. Imagining economy differently implies to take notice of everything we do to ensure the material and immaterial functioning and well-being of households, communities and nations. It relates to an economy that can reflect a wider reality. A reframed economy regards any actor as an economic actor, being able to contribute in reshaping economies towards environmental and social well-being (Gibson-Graham, Cameron and Healy 2013:3).

Approaches of 'Social Agriculture' debated in the Western World can be connected to the developmental model of 'Buen Vivir', presented by Acosta (2017). Social agriculture is a potential solution to prevent rural depopulation, to stimulate re-population of abandoned areas or to foster social cohesion in rural communities (Cervinka et al. 2010). It connects to approaches like 'green care' as integral concepts on social and societal change as well as solidarity economy and social inclusion (Haubenhofer et al. 2012; Sempik et al. 2010; Wiesinger et al. 2013).

Combining those concepts and unlocking social and economic capacities it generates synergy effects for users as well as for suppliers and for the community in general. Social agriculture has the additional effect, that local people profit directly, also by necessary infrastructure development like mobility structures or cultural events. They allow new institutional arrangements in social, educational and healthcare services, innovative care-settings; eco-social development, resilient communities and strategies for remote areas; Education for Sustainable Development, nature- and animal based education. Additionally, the approach relates to a global interconnection of Fair Trade.

4.3 A Fair Trade University

In order to secure the economical survival of indigenous communities, transcontinental and intercultural learning potentials are given in the field of 'Fair Trade'. In order to avoid rural exodus and depopulation, especially younger generations need to support and preserve their life chances. Fair Trade should therefore be regarded as a core element of this version of an alternative Indigenous University. It addresses solidary economy, sustainable global economical cycles and transformational education.

A Higher Education approach that connects transformative Higher Education and the development of fair and sustainable trade within the global economical cycle brings about concrete options for transformational education and project-based learning. It connects existing best practices like the 'tea campaign', practiced in the 1980s and 1990s at the Free University of Berlin, Germany, within their project seminars 'Social Entrepreneurship in Economics'.

This approach might be interconnected and applied to Latin America, to the product of coffee and other suitable products. It has to be tested regarding potential for prototyping and regarding scalability. It will be analyzed regarding possibilities to support Fair Trade in global economical cycles and to contribute to socio-ecological development of indigenous people, as well as Education for Sustainable Development, the support of Human Rights of Threatened indigenous people especially within the Colombian peace process. Based on Higher Education production projects, the global problem of poverty, segregation and land exodus like this, can be fought.

A Fair Trade approach particularly offers innovative perspectives for a global fair economical cycle. It carries a lot of transformational potential. Given the monopolist market structures in Colombia and many other countries, Fair Trade as an educational approach in Higher Education can support sustainability, material existence and the development of value chains and circles in sustainability.

5 Designing Global Economical Circuits as Educational Circuits

Putting eco-social solutions at the global level into action, Higher Education can support sustainable economies. Due to its integrative and transformative nature, it is also an instrument for implementing the 2030 agenda for sustainable development.

This approach supports the shift from Millennium Developmental Goals (MDGs) to Sustainable Development Goals (SDGs), framed within international cooperation. It connects piloting and implementing sustainable development within global system innovation. It addresses SDG 2 sustainable land use, as well as connecting it to sustainable agriculture. It connects to SDG 3 Healthy Lives, insofar sustainable living is addressed. SDG 4 Education for Sustainable Development are placed in the center, insofar students are interconnected with transnational initiatives in sustainable and problem-, as well as solution based initiatives and learning arrangements. SDG 6 is addressed, insofar agriculture and economical cycles will be related more towards sustainability. SDG 8 addresses global economical cycles and SDG 12, the world of sustainable production patterns and sustainable consumption.

As the global economical cycle as an educational cycle especially can and will be relevant to sustainability education, connections to other universities and projects for sustainable development will be of interest. Insofar SDG 17 is addressed, when dealing with the principle of sustainable supply in value chains of purchase and delivery. Especially the glocal approach, the solidary transcontinental cooperation of different educational perspectives of a good and sustainable life can support the cooperation, which values indigenous cultures and their concept of nature and cosmology.

5.1 Participatory Learning and Participatory Creation for Social Innovation

With participation at the core, deliberative methods are a way to inclusiveness and inclusion. The approach relates to perspectives of social practice, which means that the social practice of creating inclusive spaces for socio-economic justice and reform has to be reflected in process. How can this approach reframe Higher Education as an inclusive space? How can it become a global practice of collaboration, involving a wide range of actors including individuals, civil society actors, state authorities and private companies? How can the 'living lab' approach work as a practice of inclusion in education and organizing social and societal change?

Deliberative methods in these processes will be at the core. Their common features are (1) getting relevant information about the issues considered; (2) having ample opportunity for free and open discussion between citizens and researchers, policy actors or other actors (3) encouragement to discuss information and positions and as well as consider each other's views (4) before finally making decisions or giving recommendations for action (Abelson et al. 2003; Degeling et al. 2015).

From an organizational education perspective, inclusion and exclusion relate to economical, ecological, social, cultural and educational dimensions in regional multi-stakeholder settings and rationalities. Where innovation labs (Adler and Weber 2018) can become a core element and a methodological framework for a transformative system of Higher Education must be considered.

The process approach of innovation labs as spaces of multi-stakeholders-engagement between research, economy, and society can offer participation and co-productive social innovation. The broad and multidisciplinary field of research discusses them in different research strands like innovation- and network-theories, in theories of social spaces and social development, and in theories of political participation and deliberation (Weber 2014).

5.2 Discursive Knowledge in Participative Action

Participatory approaches and methods are regarded as knowledge in action and discursive process (Bormann et al. 2016; Bormann and Hamborg 2016; Hamborg 2016). In present policy statements like OECD papers, the development of innovation competences and problem-based, participatory learning in Higher Education much is asked for (Hoidn and Kärkäinen 2014). To implement design-thinking strategies within Higher Education, connections are made on 'transformative learning' (Moore

2005) or the 'Entrepreneurial University' (Scharmer and Käufer 2000). Critical positions reflect on, whether universities are prepared for such innovative learning methods and for design approaches developed by novices (Razzouk and Shute 2012). Weber (2014) shows, that for an implementation of those approaches in academic contexts one must take into account different levels of prototyping: (1) Many approaches primarily address the 'material' level, which is related to products and processes. (2) At the second level of building social systems, it is to be reflected, how design-approaches support sociopolitical integration of different rationalities for addressing societal 'wicked problems' (Weisbord 1989; Weber 2000, 2005). (3) At the third level of subjects and conscience, ethics and personal transformation, it is to be asked, how transformational learning and education connects to the education of societal actors. It addresses the question, how 'deep innovation' (Scharmer 2007; Scharmer and Käufer 2000) can be brought about, in order to be able to integrate different rationalities and world views in a societal future process. These three levels need to become relevant for an implicit and explicit modeling of a Higher Education approach in the field of sustainability studies.

Sustainability Higher Education innovation laboratories in a global Fair Trade University then can be discussed in an organizational context of co-production (Ballon et al. 2005). It can be regarded as social system development in the sense of a "user-centric research-methodology" (Eriksson et al. 2005:4) and thirdly can be seen as an innovation-lab approaches in the sense of developing a systemic innovation approach (Feuerstein et al. 2008) for the turn and path creation into sustainability.

An academic, teaching-centered practice of interdisciplinary invention can also be made useful for international and interconnected intercultural research and learning arrangements of systemic, reflexive as well as anticipative knowledge (Renn et al. 2007). In total it relates to the potential of 'Design-Research-Teaching' for Sustainability and supports, what the philosopher Innerarty (2013) calls the 'democracy of knowledge'.

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