World Sustainability Series

Walter Leal Filho
Mark Mifsud
Chris Shiel
Rudi Pretorius *Editors*

Handbook of Theory and Practice of Sustainable Development in Higher Education

Volume 3

Springer

World Sustainability Series

Series editor

Walter Leal Filho, Hamburg, Germany

More information about this series at http://www.springer.com/series/13384

Walter Leal Filho · Mark Mifsud
Chris Shiel · Rudi Pretorius
Editors

Handbook of Theory and Practice of Sustainable Development in Higher Education

Volume 3

Springer

Editors
Walter Leal Filho
FTZ-ALS
HAW Hamburg
Hamburg
Germany

Chris Shiel
Department of Life and Environmental Science
Bournemouth University
Poole
UK

Mark Mifsud
Centre for Environmental Education and Research
University of Malta
Msida
Malta

Rudi Pretorius
Department of Geography
University of South Africa Science Campus, Florida
Johannesburg
South Africa

ISSN 2199-7373 ISSN 2199-7381 (electronic)
World Sustainability Series
ISBN 978-3-319-47894-4 ISBN 978-3-319-47895-1 (eBook)
DOI 10.1007/978-3-319-47895-1

Library of Congress Control Number: 2016954518

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

We are pleased to introduce the third volume of the "Handbook of Theory and Practice of Sustainable Development in Higher Education".

This publication, which consists of a set of volumes, introduces many of the papers discussed and presented at the World Symposium on Sustainable Development at Universities (WSSD-U-2016), which was held at the Massachusetts Institute of Technology (MIT), in Cambridge, MA, USA in September 2016.

The aims of WSSD-U-2016, consistent with the goals of the WSSD-U series, were:

i. to provide universities all round the world with an opportunity to display and present their work (i.e. curriculum innovation, research, activities, practical projects) relating to education for sustainable development at university level;
ii. to foster the exchange of information, ideas and experiences acquired in the execution of projects, from successful initiatives and good practice;
iii. to discuss methodological approaches and projects which aim to integrate the topic of sustainable development in the curriculum of universities;
iv. to network the participants and provide a platform so they can explore possibilities for cooperation.

Last but not least, a further aim of the event was to document and disseminate the wealth of experiences available today.

To this purpose, the "Handbook of Theory and Practice of Sustainable Development in Higher Education" has been produced.

This volume is structured around two parts. Part I, under the heading "Sustainability Models and Systems" outlines a range of models and formats which have been experimentally tested and implemented, with a view to catering for the inclusion of sustainability matters in university systems and programmes.

Part II, titled "Implementation Strategies", demonstrates many of the means and formats authors have used to allow a due emphasis on matters related to sustainable development to be provided at their universities, sometimes working against unfavourable political and social settings.

We thank the authors for their willingness to share their knowledge, know-how and experiences, as well as the many peer reviewers, which have helped us to ensure the quality of the manuscripts.

Enjoy your reading!

Hamburg, Germany — Walter Leal Filho
Msida, Malta — Mark Mifsud
Poole, UK — Chris Shiel
Johannesburg, South Africa — Rudi Pretorius
Winter 2016/2017

Contents

Part I
Sustainability Models and Systems

Designing Sustainable Consumption and Production Systems in Higher Education Institutions: The Case of Solid Waste Management

Danesto B. Anacio

Abstract

The vast potentialities for higher education institutions (HEIs) in designing and implementing sustainable consumption and production systems need to be developed in this age of Sustainable Development Goals (SDGs). To further elucidate this argument, various studies show that the material recovery potential of discarded solid wastes in universities is more than 50 %. Focus is given in Philippine HEIs, wherein recoverable solid wastes were identified in faculty rooms of three HEIs in Baguio City, Philippines, using a waste assessment and characterization survey (WACS). Results show that around 90 % of solid wastes in faculty rooms are potentially recoverable, as residual wastes only account 6–11 %. It is projected that 75,968 kg/day of solid wastes are generated annually in Philippine HEI faculty rooms alone, and around $537.66 can be monetized from recoverable wastes in such rooms per campus per school year. The untapped monetary equivalents of recoverable solid wastes should prompt partnerships between HEIs and recycling and or manufacturing companies, local government, non-profits, and non-government organizations to recover and monetize reusable and recyclable wastes. Such arrangements would eventually close material consumption and production loops not only in the Philippines but also in an ASEAN (Association of Southeast Asian Nations) or global scale, and therefore reduce resource footprints generated by educational institutions.

Keywords

Sustainable development · Waste monetization · Waste recovery · SDGs

D.B. Anacio (✉)
School of Environmental Science and Management (SESAM),
University of the Philippines Los Baños College, 4031 Los Baños,
Laguna, Philippines
e-mail: dbanacio@yahoo.com

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_1

1 Waste Generation in Higher Education Institutions (HEIs)

It has been asserted by Alshuwaikhat and Abubakar (2008) that waste production in colleges and universities is analogous to the operation of large scale industries, business establishments and health care facilities. The population of students and employees, workshops and laboratory activities, cafeterias and food related establishments, infrastructure repair and maintenance, and the utilization of energy and materials equate to a positive correlation in generated wastes. As a result, significant environmental impacts arise from the volume and variability of materials required to support such university operations. It is therefore important for universities, and educational institutions in general, to manage solid wastes in a sustainable and efficient manner.

Implementing practical and effectively functioning SWM systems however, need to first consider the nature of solid wastes since waste characteristics vary according to source. Identifying the type of wastes produced in a particular location is important in order to determine appropriate and specific waste management programs, such as waste reduction, reuse, recycling, composting and or combustion programs and technologies (Thompson and Wilson 1994; Tchobanoglous et al. 1996; Thompson and van Bakel 1995; Rada et al. 2009; Premakumara et al. 2011; Theofanidis et al. 2012; Ionescu et al. 2013; Guo and Liu 2014; Eriksson et al. 2014). In addition, identifying the type and volume of generated wastes allow planners to design applicable waste treatment and disposal strategies for each waste type produced, and allot necessary resources for implementing appropriate SWM systems (Lininger et al. 2000; Nilanthi et al. 2007; Yousuf and Rahman 2007; Ragazzi and Rada 2008; World Bank 2009; Tunesi 2011).

In the case of universities, determining waste characteristics from specific departments or clusters provide avenues for establishing sound waste management strategies. Solid waste management systems adapted from waste characteristics and conditions with specific scales and contexts in consideration, will be much more effective than systems simply imitated somewhere else (Armijo de Vega et al. 2008). The university cafeteria for example generates a huge volume of food refuse, thus, waste management systems in place should be able to prioritize reducing, recycling, and storing food-related wastes (VIT, n.d.; Mbuligwe 2002; Smyth et al. 2010). In addition to food wastes are food and beverage packaging wastes, as foodstuffs utilize a great deal of packaging materials (Arvanitoyannis and Bosnea 2001).

Waste characterization studies in HEIs reveal that a high percentage of recoverable materials exist in the waste stream, as shown in a number of literature reviews (Anacio 2011; Purwana et al. 2012). Universities in developed countries, for example Brown University and University of Florida in USA have 45 and 53 % respectively of recyclable wastes from their daily generated wastes (UF Sustainability Task Force 2002; Brown University 2004). The Prince George campus of University of Northern British Columbia (UNBC) in Canada could recover 70 % of weekly generated wastes through various waste reduction schemes (Smyth et al. 2010). In Central America, the Autonomous University of Baja California (UABC) Mexicali I campus, Mexico, could recover 65 % of the daily waste output (Armijo de Vega et al. 2008). Universities in developing countries on the other hand, present higher figures for recoverable wastes. Mbuligwe (2002) revealed that 71–86 % of generated solid wastes in Tanzanian universities could be reduced. In Philippine HEIs, around 90 % of solid wastes are potentially recoverable in faculty rooms of three universities in Baguio City, and residual wastes (non-recyclable and non-biodegradable materials) only account 6–11 % (Anacio 2011). Recoverable wastes in Philippine universities further reveal that monetary equivalents could have been derived if efficient material recovery programs and systems were in place.

2 Monetizing Garbage in Philippine HEIs

A market is existing in the Philippines for recyclable wastes (Table 1). Around 70 recycling companies exist in the Philippines as identified by the National Solid Waste Management Commission (NSWMC 2009). Using data for the market value of recoverable wastes by the NSWMC, sorted wastes from Saint Louis University (SLU), University of Baguio (UB), and University of the Cordilleras (UC), all in Baguio City, Northern Philippines, were monetized and valued per kilogram by Anacio (2011). Monetary amounts derived from recoverable wastes in each HEI are presented in increasing order: $0.28/day/faculty room in UC, $0.04/day/faculty room in SLU and $0.04/day/faculty room in UB ($1.00 = P43.00) (Anacio 2011).

It was also discovered that a high percentage (by weight) of the wastes generated in the three HEIs are recoverable and with monetary equivalents. The quantity of paper wastes disposed in UC is 46 % while UB and SLU generate 14 and 12 % respectively. For biodegradable wastes, SLU generates the highest percentage with 45 % while UB and UC produce 28 and 20 % respectively (Table 2). Rubber, metal, glass and tetra pak wastes are generated for all the HEIs, but account less than 1 % from the total characterized wastes, and thus were not included in the table.

Extrapolating Anacio's data (2011) with the current 2374 HEI campuses in the Philippines (CHED, 2014); with an estimated average of 25.7 personnel per faculty room; generating around 1.6 kg per day per room; and an average of 20 faculty rooms per campus, a total of 75,968 kg/day of solid wastes are generated annually in Philippine HEI faculty rooms alone. Furthermore, around $537.66 can be monetized from recoverable wastes per campus in a given school year (given that around $0.12 can be recovered from faculty room wastes per day in a ±228 day school year) (Anacio and Gomez 2016). It should be especially noted however that

Table 1 Market values of recoverable materials as of 2008 (NSWMC 2009) (adapted from Anacio 2011; Purwana et al. 2012)

Recyclable item	Estimated factory price ($/kg) (except ink cartridges) in increasing order
Glass bottles	$0.01 to $0.07
Assorted papers	$0.05
Corrugated carton	$0.07
Glass cullet	$0.12
Tin can	$0.12
Old newspaper	$0.14
Used white paper	$0.21
GI sheet	$0.23
Low density polyethylene (LDPE)	$0.23
Car battery	$0.27
Steel and Iron (ordinary)	$0.28 to $0.33
High density polyethylene (HDPE)	$0.30
Printer casing plastics	$0.30
PET bottles w/caps and labels	$0.35
Polyethylene (PET) bottles w/o caps and labels	$0.47
Stainless Steel	$1.63
Ink cartridges	$2.33 to $7.00 per piece
Copper wire (reddish)	$8.14
Copper wire (yellowish-red)	$13.04
Copper wire (yellowish in thin strands)	$14.35

Note ($1.00 = P43.00)

Table 2 Waste composition by weight volume of faculty room wastes in the three HEIs (adapted from Anacio 2011; Purwana et al. 2012)

	Papers (%)	Plastics (%)	Glasses (%)	Food waste (%)	Biodegradable (%)	Textile (%)	Residual wastes (%)	Total (%)
UB	14	23	2	27	28	0	6	100
SLU	12	14	2	17	45	0	10	100
UC	46	14	1	7	20	1	11	100

these figures account solid wastes from rooms where faculty or teaching personnel spend a particular amount of their time. Non-teaching staff, students, and visitors or non-campus personnel have been excluded in the analysis, as such, if the source of the whole waste stream in the campus is accounted for, monetary values could be tripled or even quadrupled. The total percentage of total recoverable wastes however would only vary slightly.

3 Creating Sustainable Consumption and Production Patterns in the Campus

One practical avenue for integrating responsible consumption and production for universities, and even in global economic systems for that matter, could start in the solid waste management set-up (Purwana et al. 2012). As universities aim to reach out to communities through research and instruction, various HEIs have already taken steps towards sustainability by including solid waste management as part of the agenda. Harvard University for example adopted its Sustainability Principles in 2006, which aims to reduce the University's greenhouse gas emissions by 30 % (from a 2006 baseline) in 2016, reduce waste per capita 50 % by 2020, and an aspirational goal of eventually becoming a zero-waste campus, among other sustainability goals and projects ("Harvard Sustainability Plan" 2014). In Boston University, a majority of the 9943-ton wastes (excluding construction projects) in 2014 was almost recovered, wherein 67 % was incinerated at a waste-to-energy facility, and 33 % was diverted through recycling (18 %), composting (12 %), and by donating it for other uses (3 %) (Boston University, n.d.). These and other similar waste related efforts from other universities, which can be emulated for university waste management systems, are shown in Table 3.

4 Recognizing Other Institutions for Promoting Sustainable Consumption and Production Patterns

The Talloires Declaration in France, an international agreement signed by over 350 university presidents and chancellors in over 40 countries, committed to implement sustainable practices, reverse environmental damage, reorient research activities and enhance outreach in colleges and universities (ULSF 1990). It is possibly the best known commitment for HEIs in promoting sustainability and sustainable development principles, although other initiatives around the world are also existing for the same reasons. For example, the American College & University Presidents Climate Commitment encourages individual presidents to take steps toward institutional plans in reducing carbon emissions and adopting energy efficiency policies (ACUPCC 2007). The Baltic 21 has also highlighted the role of education as a means to achieve broader objectives on sustainable development (Baltic 21 2004). Others, like the International Sustainable Campus Network (ISCN), the Global Higher Education Sustainability Partnership (GHESP), the COPERNICUS Alliance (European Network of Higher Education Institutions), and the Association for the Advancement of Sustainability in Higher Education (AASHE), especially through its Sustainability Tracking, Assessment & Rating System (STARS), provide forums, platforms and recognition for empowering HEIs to exchange good practices

Table 3 Waste management efforts in selected universities

University	Waste management related goals	Achievements and or awards	Programs on solid waste management
Harvard University[a]	• Reduce 50 % (2006 baseline) waste per capita by 2020	• 53 % of total waste recycled and composted (2013) • 54 % decrease in food waste	• Recycle or dispose of hazardous and electronic materials in a responsible and ethical manner, with a priority to minimize the use of hazardous materials, as appropriate • Reduce the amount of electronic waste generated per capita by 2020
Boston University[b]	–	• 67 % wastes in waste-to-energy facility • 33 % of total waste diverted	• Materials being recycled: aluminium, cardboard, glass, paper, coffee cups, plastics, and clean milk and juice containers, batteries, cell phones, computers and other electronic waste, fluorescent light bulbs and ballasts, ink & toner cartridges, appliances, metals, and construction materials • Employees of the University can swap unused University-owned items for free • Donating furniture for reuse overseas through the Institutional Recycling Network (IRN) • "Zero Waste" commencement • Yard waste composting program • Reusable mug program to provide a sustainable alternative to the use of paper cups and single use plastic bottles • Reusable mug discount at every coffee-serving location on campus • Surplus Asset Management program for furniture reuse on campus • Bottle Filling Station installation • Paperless payroll • Electronic recycling through the Institutional Recycling Network (IRN) and Allied Computer Brokers • Online chemical reuse inventory for laboratories on campus • Reduced print quotas for all students with a fee for exceeding allocation • Double-sided printing available at all on-campus print centre locations • All course catalogues, student schedules, and directories available online

(continued)

Table 3 (continued)

University	Waste management related goals	Achievements and or awards	Programs on solid waste management
Princeton University[c]	• Increase household recycling percentage from 38 % (2007) to 50 % (2012) • Reduce 40 % (2006 baseline) waste per capita by 2020 • Recycle at least 95 % from demolition and construction waste • 100 % use of recycled disposable paper products by 2009 • Reduce the use of disposable paper products	• Cleaning chemicals purchased decreased by 31 % since 2010, although a 28 % increase has also been noted • Student print quota instituted in 2009, reducing 33 % of print-outs in computer clusters and public libraries • Installation of 200 bottle filling stations in 2010, reducing 100,000 bottled water purchases per year • Campus waste decreased by 34 % per capita, while recycling rate increased to 44 % since 2006	• Increase move-out donation options for items including clothing, food, toiletries, schools supplies and books, and increase donation opportunities through the University's Surplus Program • Partnership with a local company to recycle food waste • Roll out a mixed recycling program across campus in parallel with an educational campaign and new campus labelling system to increase recycling rates • Recycle 95 % of construction and demolition debris for new and renovated buildings
Appalachian State University[d]	• 90 % diversion by 2022 • Conduct a Comprehensive Waste Audit • Expand Reuse, Recycling and Composting Efforts • Institute an Environmentally Preferable Purchasing Program • Encourage Campus Engagement	• Waste diversion rate from 17 % (2007) to 40 % (2010) • $7187 was recovered from scrap metal, cardboard, and print cartridges in 2011	• Collection point for CDs, DVDs, printer cartridges, cell phones, batteries, plastic bags, CFL bulbs, and rigid plastics • Partnership with recycling company for electronics recycling program • Operational composting facility and program • Goods exchange event • Garage sale for reusable items
Wake Forest University[e]	–	• Over 1600 kg of food and paper waste composted in 2014 • Over 11 tons of discarded goods diverted from the landfill, and over 700 kg of paper collected for recycling in 2014	• Surplus Property Program re-purposes items on campus and facilitates the recycling of e-waste • Partnership with Gallins Family Farm, pre-consumer waste turned into compost • Dining hall compost campaign • Partnership with UpCycle Life for recycling used billboards and banners • End-of-year move-out waste reduction campaign

(continued)

Table 3 (continued)

University	Waste management related goals	Achievements and or awards	Programs on solid waste management
Rutgers University[f,g]	–	• Achieved a 67 % recycling material diversion rate, toward a goal of 85 % by 2015 • Implemented single-stream recycling. All recyclables can be mixed together—no sorting needed • Won the RecycleMania Gorilla Prize (2006–2011) for having the highest tonnage of recyclables • Won EPA'S "WasteWise Partner of the Year" (2007), diverting 15,800 tons of material, $840,000 savings in landfill costs	• Waste reuse, reduction and recycling (RecycleMania) programs • Purchase of products manufactured with recycling content • Green Purchasing policy
Arizona State University[h,i]	• Zero waste by 2015	• 25 % campus-wide diversion rate • Partnered with a local farm to repurpose food and organic material into usable compost • 32 % savings in overall waste service costs	• Comprehensive programs on –Waste aversion –Recycling –Organic waste management –Reuse –Hazardous material management –Communications and engagement
Swansea University[j,k]	• Achieve zero waste to landfill by 2015/16 • Reduce waste mass (tonnes) per m^2 to 0.005 by 2015/16 • Increase % recycled waste proportion to 48.8 by 2015/16	• Food cost savings of over $13,700 per year	• Waste reduction in campus catering • Other waste management plans incorporated in Swansea Carbon Management Plan 2010–2020

(continued)

Table 3 (continued)

University	Waste management related goals	Achievements and or awards	Programs on solid waste management
Chinese University of Hong Kong[l]	• Launching of Waste Management Policy and Guidelines • From 2012–2017 Reduce waste to landfill by 12 % per capita Cut paper consumption by 50 % Make food waste management compulsory for all canteen caterers as new contracts commence	• Reduction by 70 % of solid waste per capita from 2006 to 2012	• Financial Information System used by the Business Office store purchase orders and tender documents electronically, with substantial paper savings; hardcopies of Student Computing Account Information no longer issued • A 2-year 'Love Food Hate Waste @ CUHK: Education Campaign and Food Waste Reduction and Recycling Programme' launched in September 2013 to reduce food waste from campus with multiple strategies • Obsolete computers and electrical appliances collected by the Business Office for donation through charities to people in need; old fluorescent tubes collected for disposal to licensed treatment facilities • Construction and demolition waste generally reused, sold, or otherwise sent to public fill (inert wastes) for land reclamation • Horticultural/landscaping waste collected for composting • Reuse of unwanted furniture • Annual recycling events for students upon hostel retreat every year • Hazardous waste management • Decentralized and individual waste reduction initiatives of student bodies and offices • Waste Reduction Incentive Scheme
The University of Queensland[m,n]	• Identify current procurement, use and disposal practices • Develop Key Performance Indicators which will guide the implementation of waste minimisation strategies • Develop policies and strategies that will ensure that the university acts in an ethically and	• More than 40 recycling stations established • 20 different waste types collected	• Installation of water refilling stations • Public place recycling program • Water and recycling poster series

(continued)

Table 3 (continued)

University	Waste management related goals	Achievements and or awards	Programs on solid waste management
	environmentally responsible manner whilst reducing the carbon footprint associated with the purchase, use and disposal of products and services acquired by the university • Identify the implications of the new state waste levy on the university and investigate funding opportunities that aid the implementation of waste minimisation strategies • Minimise waste in the procurement process, ICT infrastructure, and reuse, recycling and disposal strategies		

[a]Harvard Sustainability Plan (2014). "Harvard University Office for Sustainability"; [b]Boston University (no date). "Waste"; [c]Princeton University (no date). "Waste Reduction"; [d]Appalachian State University (2012). "Waste Reduction Strategic Plan: Working toward a Zero Waste Campus"; [e]Wake Forest University (no date). "Waste Reduction and Recycling"; [f]Rutgers University (no date). "Green Purchasing"; [g]Waste Management Inc. (2013). "Rutgers University is recycling more, and thinking greener than ever"; [h]Arizona State University (no date). "ASU Roadmap to Zero Waste"; [i]Waste Management Inc. (2013). "Creating valuable environmental solutions for Arizona State University"; [j]Swansea University (2010). "Swansea Carbon Management Plan 2010–2020"; [k]Swansea University (2014). "Reducing Food Waste at Swansea University"; [l]Chinese University of Hong Kong (no date). "Sustainability at CUHK: Waste Reduction"; [m]University of Queensland (2010). "UQ Waste Minimisation Plan"; [n]University of Queensland (no date). "Sustainability: Recycling and Waste"

and improve current practices concerning sustainability issues. On the other hand, in spite of these positive steps for creating green campuses, curriculums, and communities; a holistic approach to embedding sustainability and specifically cleaner consumption and production systems within HEIs is lacking (OECD and HE4SD 2007).

In addition to university-led efforts for mainstreaming sustainability in the campus, business firms have been active participants in greening campuses. Waste Management Inc. (WMI) with its Think Green Campus Model, has partnered with universities such as University of New Hampshire, Rutgers University and Arizona State University in improving their waste management systems and facilities. The Think Green Campus Model is a systematic approach based on best practices derived from the work of WMI and other stakeholders and involves six general steps: (1) establishing goals, (2) conducting an assessment, (3) developing applicable programs, (4) implementation, (5) measuring and reporting through WMI's RADAR tool, and finally, (6) continued evaluation and improvement of implemented programs.

Government ministries and departments are also helping create favourable conditions by recognizing notable institutions and their waste management efforts. The US Environmental Protection Agency (US-EPA) with its WasteWise Program has cited Rutgers-The State University of New Jersey, Suffolk University, Eastern Illinois University (EIU), Medical University of South Carolina, and Miami University as notable educational institutions for their waste management programs.

In the Philippines, the Department of Environment and Natural Resources (DENR) with its National Search for Sustainable and Eco-friendly Schools, has been giving awards to notable and commendable sustainability and environmental programs among elementary, secondary, and tertiary educational institutions since 2009. Similar with other universities around the world, waste reduction and recycling endeavours are also in place in Philippine universities, such as encasements for dropping used plastic bottles, as can be seen in De La Salle University Dasmariñas (Fig. 1). Other practices include back-to-back paper printing, waste segregation, and food waste diversion for animal feed, as discovered in the three universities in Baguio City, as well as other HEIs in the Philippines.

The existence of recycling companies in the country handling plastic, paper, computer electronics, tin and other metals, glass, tetra pak, car batteries and rubber wastes should provide further impetus for material consumption and production cycling in the country. If cross-border movement of recyclable materials in Asia is considered, the Association of Southeast Asian Nations (ASEAN) region presents additional opportunities to develop an efficient material-cycle society, especially with the active participation of universities (Hashi and Mori 2005; Purwana et al. 2012).

5 A Focus on ASEAN: Opportunities and Issues for HEI Sustainable Consumption and Production Patterns

The Association of Southeast Asian Nations (ASEAN) was established in August 8, 1967 in Bangkok, Thailand, with the signing of the ASEAN Declaration (Bangkok Declaration) by Indonesia, Malaysia, Philippines, Singapore and Thailand (ASEAN 1967). From the original five founding countries, Brunei Darussalam joined on January 7, 1984, Viet Nam on July 28, 1995, Lao People's Democratic Republic and Myanmar on July 23, 1997, and the tenth member, Cambodia on April 30, 1999. ASEAN's emblem shows an image of rice stalks bundled together at the center, representing the dream of ASEAN as a region of countries in Southeast Asia bounded together in friendship and solidarity (ASEAN 2009).

In December 15, 1997 in Kuala Lumpur, Malaysia, ASEAN's leaders adopted ASEAN Vision 2020, envisioning a "concert" of Southeast Asian Nations, a "community of caring societies" and an "ASEAN Economic Region in which there is a free flow of goods, services and investments, a freer flow of capital, equitable economic development and reduced poverty and socio-economic disparities" (Severino and Menon 2013; ASEAN 1997). Ten years after, in January 2007, the establishment of an ASEAN community was moved from 2020 to 2015 (ASEAN 2007).

As a result of the shortened timeline, the Roadmap for an ASEAN Community (2009–2015) was formally adopted in March 1, 2009 in Cha-am, Thailand during the 14th ASEAN Summit (ASEAN 2009). This plan thus replaces the earlier blueprint for ASEAN Vision 2020, and the new 2015 action plan constitutes the following components: (1) ASEAN Political-Security Community Blueprint, (2) the ASEAN Socio-Cultural Community Blueprint, (3) the Second IAl Work Plan (2009–2015), wherein these three were also signed and adopted during the same summit, and the (4) ASEAN Economic Community Blueprint, which was signed and adopted earlier during the 13th ASEAN Summit on November 20, 2007 in Singapore. Each ASEAN member state shall ensure, although without clear sanctions if one fails to do so, the timely implementation of the Roadmap in order to achieve an ASEAN Community by 2015.

These developments, in addition to the recently signed Trans-Pacific Partnership on February 4, 2016, present a number of implications and opportunities for promoting sustainable consumption and production patterns. The role of recycling companies as key partners for recovering wastes is an unrecognized potential, especially in the ASEAN region. ASEAN countries bordering non-ASEAN countries, can capitalize on existing recycling companies in operation. Recycling firms in Taiwan for example have grown in number from about 100 during the 1980s and 1990s, to more than 2000 in 2013, earning at least $2.2 billion in revenue as of 2012 (The Diplomat 2013). Additionally, Malaysia's Lee Soon Seng Plastics Industries Sdn Bhd has seen growth, as a result of these recent developments (Toloken 2015). ASEAN-situated firms on the other hand, such as Cimelia Resource Recovery in Singapore and Thailand, and Global E-Waste in Malaysia,

Fig. 1 Metal encasement for collecting recyclable PET and other plastic bottles in De La Salle University Dasmariñas (Photo courtesy of Ms. Meycel Amarille)

operate e-waste recycling and refinement plants, and thus would be able to handle e-wastes from north-western ASEAN members (Purwana et al. 2012; Algie 2010). Tetra Pak, which develop product packaging and currently in operation in five ASEAN members (Indonesia, Malaysia, Philippines, Singapore, and Thailand), recycle used Tetra Pak cartons. As of 2014, approximately 651,000 tons of Tetra Pak beverage cartons globally were recycled, with the company aiming to have a 40 % recycling rate by 2020 (Tetra Pak, n.d.).

These and other recycling companies near and within ASEAN allow HEIs from the 11 member countries (as shown in Table 4) to market their recoverable materials and serve as partners for recycling initiatives. Universities could also implement education for sustainability programs through guided trips in the recycling processes, material life cycle assessment studies, and even recycling technology

Table 4 Estimated HEIs per ASEAN country and its related government entity

ASEAN country	Estimated number of HEIs (more or less)[a]	Reference(s)	Concerned Government Entity
Indonesia	4600	NIAD-UE (n.d.)	Ministry of Research, Technology and Higher Education; Ministry of Education and Culture; Ministry of Religious Affair; Ministry of Health
Philippines	2400	CHED (2014)	Commission on Higher Education
Malaysia	1300	Malaysia University Portal (n.d.), eTawau (n.d.), Chai (2007)	Ministry of Higher Education
Vietnam	400	Clark (2014)	Ministry of Education and Training
Myanmar	200	JICA (2013)	Ministry of Education
Thailand	200	Bvornsiri in Welch (2011)	Office of the Higher Education Commission
Singapore	200	Ministry of Education (n.d.)	Ministry of Education
Cambodia	90	Kwok et al. (2010), World Bank (n.d.)	Ministry of Education, Youth and Sport
Laos Peoples Democratic Republic	40	World Bank (n.d.)	Ministry of Education and Sports
Brunei Darussalam	10	Oxford Business Group (2013)	Ministry of Education

[a]Due to the growth of HEIs being established in the ASEAN region, as well as the availability of data concerning the exact number tertiary education institutions, this paper rounded up exact figures derived from the various references

development and testing. More importantly, these set-ups could also help bridge learning processes related to sustainable consumption and can be promoted on the micro-level among students, teaching personnel and other employees in educational organizations. Given a cradle-to-cradle approach and systems thinking for managing university solid wastes, learning takes place as an active form of influencing the organizational culture of consumption and production.

Additionally, not only ASEAN HEIs and recycling companies would benefit from such arrangements, but also manufacturing industries, local government units, and national departments and ministries concerned with higher education issues, natural resources, and national economic development. In this sense, such systems have the potential to contribute in achieving Sustainable Development Goals (SDGs), including goal 12 (ensure sustainable consumption and production patterns) and institutionalizing the agenda of higher education for sustainable development (Barth et al. 2014). A number of global HEIs are on the right track (as shown in Table 3), and hopefully, ASEAN HEIs would start to institutionalize sustainability not only in their instruction and research, but in the overall campus operations and external networks.

On the other hand, a number of key components are needed to implement sustainable consumption and production patterns in an ASEAN HEI. These components, subdivided into thematic elements and applicable variables, have been adapted from various systematic waste management analysis frameworks (Table 5) (Trivedi et al. 2015; Marmolejo-Rebellón 2013; Chen 2008; Lang et al. 2002). These applicable variables could also be used to model future scenarios regarding university implementation of sustainable consumption and production systems. Furthermore, monitoring and forecasting internal and external conditions and developments to interpret aforementioned events in ASEAN are needed, thus, threats and opportunities for these key elements are also identified (see Bryson 1995; Aguilar 1967; Bates 1985; Jain 1984).

Since this paper identifies a systems approach of including all possible stakeholders in the solid waste management scheme, developing partnerships with other institutions and sectors would be able to fill-in missing components that a university is not able to address. These could be manifested as agreements and working arrangements between manufacturers of consumed products; government entities such as national and local administrations, education departments and or ministries; private firms and consultancies; as well as the overall consumers within the university (students, employees and guests). An integrated and systematic working relationship therefore provides an opportunity to realize sustainable consumption and production patterns on a global scale.

Table 5 Systematic considerations for a university consumption-production loop in an ASEAN context

Thematic elements	Applicable variables	Strengths and opportunities	Weaknesses and threats
Cultural	• Awareness of stakeholders of waste management systems • Willingness to participate • Perception and worldviews regarding waste	• Academic culture inherent in universities could easily identify data gaps • Enculturation of sound waste management practices could be better facilitated • Diverse cultures lead to broader sustainability dissemination • Inclusion of various stakeholders in the waste management system to provide needed requirements that one stakeholder cannot provide	• Diversity of worldviews may hinder implementation of programs • Research culture may not be complemented with product application and development
Social and institutional	• Social norms • Social capital • Social arrangements and roles • Communication and coordination options • Material consumption and production patterns • Waste management sectors • Waste management practices • Demography of waste sources	• Diversity of stakeholders could be translated into social capital • Information disseminated not in individual pathways but rather targeting distinct social groups • Inclusion of various stakeholders in the waste management system to provide needed requirements that one stakeholder cannot provide	• Mismanagement issues as a result of numerous stakeholders involved • Cost allocation issues as a result of additional manpower involved
Technical and technological	• Technology options/availability • Applicable technologies • Technology providers	• University research and development could easily provide needed technologies and concepts • Partnerships with other stakeholders easily facilitated	• Funding sources need to be secured • Diversion of funds toward more technologically advanced outputs from other universities and or private firms

(continued)

Table 5 (continued)

Thematic elements	Applicable variables	Strengths and opportunities	Weaknesses and threats
	• Research and development status	• Inclusion of various stakeholders in the waste management system to provide needed requirements that one stakeholder cannot provide	
Financial	• Financial capital and available subsidies • Availability of funding agencies • Pricing of recoverable materials • Marketing set-ups for recoverable materials	• ASEAN economic integration • Trans-Pacific Partnership • Inclusion of various stakeholders in the waste management system to provide needed requirements that one stakeholder cannot provide	• Competition for funding would likely increase
Policy and governance	• Concerned stakeholders • Waste management set-up • National and local solid waste related policy frameworks • University action plans and frameworks	• Cultural and social arrangements could better facilitate and implement needed programs • Existing and related national and local government policies could be included within university and inter-stakeholder plans • Inclusion of various stakeholders in the waste management system to provide needed requirements that one stakeholder cannot provide	• Incongruity of policies in various policy frameworks of different sectors
Ecological and environmental	• Geography and terrain • Climate • Spatial and temporal allocations for waste management processes • Access to waste management sites	• University assets (land, technology, manpower, etc.) • Inclusion of various stakeholders in the waste management system to provide needed requirements that one stakeholder cannot provide	• Disasters • Climate change • Fund allocation for climate proofing and disaster resiliency

6 Ensuring the Sustainability of the University Consumption-Production Loop

With the end of the Millennium Development Goals (MDGs), the recently adopted 17 SDGs strongly promote sustainable consumption and production patterns as a global status within the next 15 years. Specifically stated in goal 12s targets are the implementation of the 10-Year Framework of Programs on Sustainable Consumption and Production (10YFP) (item 12.1); sustainable management and efficient use of natural resources (item 12.2); substantially reduce waste generation through prevention, reduction, recycling, and reuse (item 12.5); among eight other related conditions to fulfil by 2030 (UN 2014). While a number of HEIs have already started systematically addressing solid waste management in their campuses and communities, a number of additional concepts are emphasized.

Reaching out to young children about responsible consumption and production is one important move in order to prepare responsible college students in the future. Incoming freshmen students would not need to adjust studying in a campus where sustainable consumption and production is the norm. Educating, continually reminding and introducing sound waste management practises as children grow up in the educational system ensure the sustainability of waste management infrastructure, and responsible consumption and production culture. Universities need to prioritize values formation toward a sustainable society in order to achieve other initiatives towards the efficient use of resources.

Finally, a systems approach of including all possible stakeholders in the solid waste management scheme should be a standard mechanism. Developing partnerships between; manufacturers of consumed products, governments (administrative and education departments and ministries) and businesses which play a role in making "green" decisions and developing policy frameworks for waste prevention, and the consumers who are the active participants in the waste management system, must all be considered in the analysis (see Seguchi and Hotta 2013). Everyone should be included in the whole picture if SWM within the university is the issue, whether these stakeholders are participating directly in university operations or not.

Although this paper does not argue that a systems framework is not appreciated or not currently in operation in particular solid waste management systems, more effort is greatly needed to identify potential opportunities, develop necessary technologies, and remove any regulatory or legal constraints to implementation (Hering 2012). This is where the crucial role of universities for mainstreaming systems thinking and life cycle approaches for managing wastes come in, by implementing it within their campuses and eventually to the general public. Solid wastes are a resource, not only in terms of its market equivalents, as fuel for waste-to-energy technologies, or for diverting potential externalities which could otherwise be used for funding other public services. Achieving the Sustainable Development Goals by 2030 and ensuring a better and resilient society in this era of climate change rests upon sustainable consumption and production patterns, and universities have all the means for doing so, especially through its waste management systems.

Acknowledgments The author would like to thank Rudi W. Pretorius and anonymous reviewers for their inputs in earlier drafts of this manuscript.

References

ACUPCC (American College & University Presidents Climate Commitment). (2007). A call for climate leadership. www.presidentsclimatecommitment.org. Last accessed 28 Mar 2016.

Aguilar, F. J. (1967). *Scanning the business environment*. New York: Macmillan.

Algie, J. (February, 2010). Welcome to the e-wasteland. South East Asia Globe. http://www.sea-globe.com/Business/welcome-to-the-e-wasteland.html. Last accessed 28 Mar 2016.

Alshuwaikhat, H. M., & Abubakar, I. (2008). An integrated approach to achieving campus sustainability: Assessment of the current campus environmental management practices. *Journal of Cleaner Production, 16*, 1777–1785.

Anacio, D. B. (2011). Material recovery potential of faculty rooms and cafeterias in selected private higher educational institutions (HEIs) of Baguio City, Philippines. Unpublished Master's Thesis, Saint Louis University, Philippines.

Anacio, D. B., & Gomez, R. A. (2016). Material recovery appraisal of solid wastes in universities of Baguio City, Philippines. *Manila Journal of Science*. De La Salle University: Philippines.

Appalachian State University. (2012). Waste reduction strategic plan: Working toward a zero waste campus. http://sustain.appstate.edu/sites/sustain.appstate.edu/files/Waste%20Reduction%20strategic%20plan%206.4.2012.pdf. Last accessed 28 Mar 2016.

Arizona State University. (no date). ASU roadmap to zero waste. https://www.asu.edu/vpbf/documents/ASU-Roadmap-to-Zero-Waste.pdf. Last accessed 28 Mar 2016.

Armijo de Vega, C., Ojeda, B. S., & Ramírez Barreto, M. E. (2008). Solid waste characterization and recycling Potential for a University Campus. *Waste Management, 28*, S21–S26.

Arvanitoyannis, I. S., & Bosnea, L. A. (2001). Recycling of polymeric materials used for food packaging: Current status and perspectives. *Food Reviews International, 17*(3), 291–346.

ASEAN. (1967). The Asean declaration (Bangkok declaration) Bangkok, 8 August 1967. http://www.asean.org/news/item/the-asean-declaration-bangkok-declaration. Last accessed 28 Mar 2016.

ASEAN. (1997). ASEAN VISION 2020. http://www.asean.org/news/item/asean-vision-2020. Last accessed 28 Mar 2016.

ASEAN. (2009). Roadmap for an ASEAN community 2009–2015. Jakarta: ASEAN Secretariat, Apr 2009.

Baltic 21. (2004). An agenda 21 for education in the baltic sea region—Baltic 21E", Baltic 21 Series No 1/2002. www.baltic21.org/?publications. Last accessed 28 Mar 2016.

Bandara, N. J. G. J., Hettiaratchi, J. P. A., Wirasinghe, S. C., & Pilapiiya, S. (2007). Relation of waste generation and composition to socio-economic factors: A case study. *Environmental Monitoring and Assessment* , *135*, 31–39.

Bates, C. (1985). Mapping the environment: An operational environmental analysis model. *Long Range Planning, 18*(5), 97–107.

Barth, M., Adomßent, M., Fischer, D., Richter, S., & Rieckmann, M. (2014). Learning to change universities from within: A service-learning perspective on promoting sustainable consumption in higher education. *Journal of Cleaner Production, 62*, 72–81.

Boston University. (no date). Waste. http://www.bu.edu/sustainability/what-were-doing/waste-reduction/. Last accessed 28 Mar 2016.

Brown University. (2004). Brown recycling program. Brown is green. http://www.brown.edu/Departments/Brown_Is_Green/waste/recysum.html. Last accessed 28 Mar 2016.

Bryson, J. M. (1995). *Strategic planning for public and nonprofit organizations: A guide to strengthening and sustaining organizational achievement* (Rev ed.). San Francisco: Jossey-Bass.

Chai H. (2007). The business of higher education in Malaysia. Commonwealth education online. http://www.cedol.org/wp-content/uploads/2012/02/114-118-2007.pdf. Last accessed 28 Mar 2016.

CHED (Commission on Higher Education—Philippines). (2014). Higher education data: 2014 (public and private HEIs).

Chen, X. (2008). A systematic comparison of municipal solid waste management systems: Case studies of Dalian City, China and the region of waterloo, Canada". Unpublished Master's Thesis. University of Waterloo, Ontario, Canada. http://infohouse.p2ric.org/ref/48/47908.pdf. Last accessed 28 Mar 2016.

Chinese University of Hong Kong. (no date). Sustainability at CUHK: Waste reduction. http://www.cuhk.edu.hk/sustainability/en/our_work/campus/waste.html. Last accessed 28 Mar 2016.

Clark N. (2014). Higher education in Vietnam. World education news and reviews. http://wenr.wes.org/2014/05/higher-education-in-vietnam/. Last accessed 28 Mar 2016.

Eriksson, O., Bisaillon, M., Haraldsson, M., & Sundberg, J. (2014). Integrated waste management as a mean to promote renewable energy. *Renewable Energy, 61*, 38–42.

eTawau. (n.d.). Higher education in Malaysia. http://www.etawau.com/edu/IndexEducation.htm. Last accessed 28 Mar 2016.

Guo, B., & Liu, Y. X. (2014). Towards integrated municipal solid waste management: A case of Urumqi, China. *Advanced Materials Research, 878*, 3–14.

Harvard Sustainability Plan. (2014). Harvard University office for sustainability. http://report.green.harvard.edu/. Last accessed 28 Mar 2016.

Hashi, T., & Hideyuki, M. (2005). Networking international recycling zones in Asia. Institute for Global Environmental Strategies (IGES). Policy Brief 1.

Hering, J. G. (2012). An end to waste? *Science, 337*, 623.

Ionescu, G., Rada, E. C., Ragazzi, M., Marculescu, C., Badea, A., & Apostol, T. (2013). Integrated municipal solid waste scenario model using advanced pretreatment and waste to energy processes. *Energy Conversion and Management, 76*, 1083–1092.

Jain, S. C. (1984). Environmental scanning in U.S. corporations. *Long Range Planning, 17*, 117–128.

JICA. (2013). Data collection survey on education sector in Myanmar: Final report. Japan International Cooperation Agency, PADECO Co., Ltd., IC Net Limited. http://open_jicareport.jica.go.jp/pdf/12113635.pdf. Last accessed 28 Mar 2016.

Kwok, K.-W., Chan, S., Heng, C., Kim, S., Neth, B., Thon, V., et al. (2010). Scoping study: Research capacities of Cambodia's Universities. Special Report. The Development Research Forum in Cambodia.

Lang, D. J., Binder, C., Stäubli, B., Schleiss, K., & Scholz R. W. (2002). A systemic approach to optimise waste management using system dynamics as an analytical tool—the case of biowaste. In *Paper presented at the European Conference: The future of waste management*, Strassbourg, France, 7–8 Oct 2002. https://www1.ethz.ch/uns/people/formerhead/scholzr/publ/conf_procee/UNS_A89.pdf. Last accessed 28 Mar 2016.

Linninger, A. A., Chakraborty, A., & Colberg, R. D. (2000). Planning of waste reduction strategies under uncertainty. *Computers & Chemical Engineering, 24*, 2–7.

Malaysia University Portal. (n.d.). Listing of universities and colleges in Malaysia. http://www.malaysiauniversity.net/full-list/. Last accessed 28 Mar 2016.

Marmolejo-Rebellón, L. F. (2013). Systemic analysis of municipal solid waste management facility sustainability in municipalities with populations below 20,000 inhabitants. *Ingeniería y Competitividad, 15*(2), 253–263.

Mbuligwe, S. E. (2002). Institutional solid waste management practices in developing countries: A case study of three academia institutions in Tanzania. *Resources, Conservation and Recycling, 35*(3), 131–146.

Ministry of Education. (n.d.). Post-secondary education: Bringing out your best with different learning styles. https://www.moe.gov.sg/docs/default-source/document/education/post-secondary/files/post-secondary-brochure.pdf. Last accessed 28 Mar 2016.

NIAD-QE. (n.d.) National institution for academic degrees and quality enhancement of higher education. BRIEFING ON INDONESIA: Quality assurance in higher education. International Affairs Division of NIAD-UE in cooperation with Badan Akreditasi Nasional Perguruan Tinggi (BAN-PT). http://www.niad.ac.jp/n_kokusai/qa/no17_BriefingonIndonesiaQAinHE_ENG_protected.pdf. Last accessed 28 Mar 2016.

NSWMC. (2009). National solid waste management commission video and ecological solid waste management kit. (DENR-EMB, CD-ROM, 2009 release).

OECD and HE4SD (Higher Education for Sustainable Development). (2007). Final report of international action research project. Based on research carried out by Dr. Andy Johnston, seconded to the OECD from Forum for the Future. www.oecd.org/dataoecd/55/4/45575516.pdf. Last accessed 28 Mar 2016

Oxford Business Group. (2013). The report: Brunei Darussalam 2013, 212 p. ISBN 1907065784, 9781907065781.

Premakumara, D. G. J., Abe, M., & Maeda, T. (2011). Reducing municipal waste through promoting integrated sustainable waste management (ISWM) practices in Surabaya city, Indonesia. *WIT Transactions on Ecology and the Environment, 144*, 457–468.

Princeton University. (no date). Waste reduction. https://sustain.princeton.edu/progress/waste-reduction. Last accessed 28 Mar 2016.

Purwana, D., Anacio, D. B., & Warokka, A. (2012). In search of environmental-oriented campus: A lesson from managing higher education institutions (Heis) strategically and profitably. *Journal of Southeast Asian Research, 2012*, 1–10.

Rada, E. C., Istrate, I. A., & Ragazzi, M. (2009). Trends in the management of residual municipal solid waste. *Environmental Technology, 30*(7), 651–661.

Ragazzi, M., & Rada, E. C. (2008). Effects of recent strategies of selective collection on the design of municipal solid waste treatment plants in Italy. *WIT Transactions on Ecology and the Environment, 109*, 613–620.

Rutgers University. (no date). Green purchasing. http://greenpurchasing.rutgers.edu/about_us.html. Last accessed 28 Mar 2016.

Seguchi, R. & Hotta, Y. (2013). Best practices and recommendations for waste reduction towards sustainable consumption. Friends of the Earth Japan and Institute for Global Environmental Strategies. Japan.

Severino and Menon. (2013). Overview. In S. B. Das, J. Menon, R. Severino & O. L. Shrestha (Eds.), *The ASEAN economic community: A work in progress*. Asian Development Bank. ISEAS Publishing.

Smyth, D. P., Fredeen, A. L., & Booth, A. L. (2010). Reducing solid waste in higher education: The first step towards 'Greening' a University Campus. *Resources, Conservation and Recycling, 54*, 1007–1016.

Swansea University. (2010). "Swansea carbon management plan 2010–2020". https://www.swansea.ac.uk/media/Swansea%20University%20Carbon%20Management%20Plan%20-%20Summary.pdf. Last accessed 28 Mar 2016.

Swansea University. (2014). Reducing food waste at Swansea University. http://www.wrap.org.uk/content/swansea-university-0. Last accessed 28 Mar 2016.

Tchobanoglous, G., Theisen, H., & Vigil, S. (1996). *Integrated solid waste management*. New York, NY, USA: McGraw-Hill.

Tetra Pak. (n.d.). An investment in our future. http://www.tetrapak.com/us/sustainability/recycling. Last accessed 4 May 2016.

The Diplomat. (December, 2013). Taiwan's recycling boom: A shining example for Asia, the world. http://thediplomat.com/2013/12/taiwans-recycling-boom-a-shining-example-for-asia-the-world/. Last accessed 28 Mar 2016.

Theofanidis, S.-A., Papagiannakis, A., Semelidis, S., & Sarigiannis, D. A. (2012). Integrated recycling of municipal solid waste in Thessaloniki. *Fresenius Environmental Bulletin, 21* (11A), 3337–3344.

Thompson, D., & Wilson, M. (1994). Environmental auditing: Theory and applications. *Environmental Management, 18*(4), 605–615.

Thompson, D., & van Bakel, S. (1995). *A practical introduction to environmental management on Canadian campuses*. Canada: National Roundtable on the Environment and the Economy.

Toloken S. (2015). How an integrated SE Asia helps global plastics firms. http://www.plasticsnews.com/article/20150805/BLOG03/150809958/how-an-integrated-se-asia-helps-global-plastics-firms. Last accessed 28 Mar 2016.

Trivedi, A., Singh, A., & Chauhan, A. (2015). Analysis of key factors for waste management in humanitarian response: An interpretive structural modelling approach. *International Journal of Disaster Risk Reduction, 14*(4), 527–535. doi:10.1016/j.ijdrr.2015.10.006

Tunesi, S. (2011). LCA of local strategies for energy recovery from waste in England, applied to a large municipal flow. *Waste Management, 31*(3), 561–571.

UF (University of Florida). (2002). Sustainability task force, final report. UF Office of Sustainability, USA. www.sustainable.ufl.edu. Last accessed 28 Mar 2016.

ULSF (University Leaders for a Sustainable Future). (1990). Report and declaration of the presidents conference. www.ulsf.org/programs_talloires_report.html. Last accessed 28 Mar 2016.

UN. (2014). Open working group of the general assembly on sustainable development goals. https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=1579&menu=1300. Last accessed 28 Mar 2016.

University of Queensland. (2010). UQ waste minimisation plan. Property and Facilities Division, Sustainability Office. http://uq.edu.au/sustainability/docs/greenprocurement/WasteMinimisationPlan.pdf. Last accessed 28 Mar 2016.

University of Queensland. (no date). Sustainability: Recycling and waste. http://www.uq.edu.au/sustainability/recycling-and-waste. Last accessed 28 Mar 2016.

VIT. (n.d.). Integrated waste management at educational institutions: A case study on Vellore Institute of Technology (VIT). http://www.3rkh.net/3rkh/files/IWM_ed_inst..pdf. Last accessed 28 Mar 2016.

Wake Forest University. (no date). Waste reduction and recycling. http://sustainability.wfu.edu/programs/waste-reduction-and-recycling/. Last accessed 28 Mar 2016.

Waste Management Inc. (2013). Rutgers University is recycling more, and thinking greener than ever. http://www.wm.com/documents/pdfs-for-services-section/Case-studies-municipal/001807_Rutgers_CaseStudy_LR%20(2).pdf. Last accessed 28 Mar 2016.

Waste Management Inc. (2013). Creating valuable environmental solutions for Arizona State University. http://www.wm.com/documents/pdfs-for-services-section/Case-studies-municipal/001807-ASU_CaseStudy_LO.pdf. Last accessed 28 Mar 2016

Welch, A. (2011). *Higher education in Southeast Asia: Blurring borders, changing balance*. New York, USA: Routledge.

World Bank. (2009). What a waste: Solid waste management in Asia (2009). http://www.worldbank.org/urban/solid_wm/erm/CWG%20folder/uwp1.pdf. Last accessed 28 Mar 2016.

World Bank. (n.d.). Conference on governance and financing of higher education–South and East Asia. http://siteresources.worldbank.org/EDUCATIONLP/Resources/Cambodia.pdf. Last accessed 28 Mar 2016.

World Bank. (n.d.) Lao PDR: Country summary of higher education. http://siteresources.worldbank.org/EDUCATION/Resources/278200-1121703274255/1439264-1193249163062/LAO_PDR_CountrySummary.pdf. Last accessed 28 Mar 2016.

Yousuf, T. B., & Rahman, M. (2007). Monitoring quantity and characteristics of municipal solid waste in Dhaka City. *Environmental Monitoring and Assessment, 135*, 3–11.

Author Biography

Danesto "Dane" Bacdayan Anacio is currently finishing his PhD in Environmental Science at the School of Environmental Science and Management (SESAM), University of the Philippines Los Baños in Los Baños, Laguna. He is also a member of the UPLB Environmental Science Society (https://www.facebook.com/uplbenvisoc), an organization of graduate students promoting sustainability and environmental science as a practice and philosophy.

Sustainable Campus Management at Freie Universität Berlin—Governance and Participation Matter

Andreas Wanke

Abstract

Sustainable campus management at Freie Universität Berlin has long placed special emphasis on climate protection and the goal of assuring sustainable development within the scope of its own institutional responsibilities. The university illustrated this by founding its own administrative unit for energy and environment management in 2001. Since then, the university has gradually implemented various initiatives and instruments such as energy efficiency programs focusing on the modernization of buildings and technical facilities, a bonus scheme for energy savings, a green IT program and several team building processes—all of which pursue the objective of realizing a systematic combination of technical, organizational and behavior-focused measures. Overall, these measures have led to a substantial drop in energy consumption of nearly 25 %, or 40 million kilowatt hours, with generally stable space utilization since the program's inception in 2001. This reduction comes in connection with annual budget savings of €3.5 million and a significant decrease in CO_2 emissions. The contribution highlights 'lessons learned' from the perspective of the sustainability manager, who has been in charge for the whole process from the very beginning in 2001. It focuses on the need for a holistic view of technology, organizational development, social learning processes and communication, as well as on the particular significance of governance aspects and stakeholder participation in terms of a whole-institution approach.

Keywords

Sustainable campus management · Energy efficiency strategies · Participation · Case study · Success factors

A. Wanke (✉)
Freie Universität Berlin, Berlin, Germany
e-mail: andreas.wanke@fu-berlin.de

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_2

1 Introduction

A special feature of the sustainability and climate change debate is the discussion related to reviving the political role of science and scientific institutions to meet their societal and social responsibility. There is no question that universities—as the core of the academic and educational system—have a special responsibility to contribute to sustainable development. This was already cited in the Copernicus Charter (1994) and the German Commission for UNESCO on Higher Education for Sustainable Development (UNESCO 2010).

But declarations alone result neither in concrete action nor success. Over the past twenty years we have seen a step-by-step, bottom-up development of universities in their role as sustainability pioneers. In the initial years, these activities focused mainly on environmental aspects with the other dimensions of sustainability being incrementally reflected in the higher education sector worldwide.

As an internationally-oriented university with more than 35,000 students, 171 degree programs, more than 5100 employees and 200 buildings with an annual budget of over €400 million, the Freie Universität Berlin considers sustainability relevant in all areas, from research and teaching to operations. Sustainability is not only the focus of diverse activities in research, teaching, and outreach activities with various stakeholders, but also its own area of campus management along with systematic climate mitigation activities. With these activities, the university is on the one hand contributing to the German energy transition. On the other hand its activities since 2000 clearly show that universities are able to make a valuable contribution to energy efficiency, which is often an underestimated or underrepresented policy field.

With regard to the challenges of climate protection one should keep in mind that energy efficiency activities—due to their precautionary orientation—clearly represent one of the most appropriate and relevant approaches to improve institutional and energy supply-based resilience. This statement is also true for the structural financial relief of universities' budgets, as well as participatory approaches, as we will see later.

The Freie Universität acknowledged its responsibility for sustainable campus management in 2001 with the creation of an energy and environment unit as part of its facility management department. With the environmental guidelines drawn up in 2004, the simultaneously launched environmental certification according to ISO 14001, the sustainability mission statement and the assignment of the sustainability and energy management unit direct to the executive board in 2015, the university has made its sustainability commitment explicit (FUB 2016).

After a brief overview of the university's energy balance, this article describes the most important activities and instruments it uses for energy and climate management, which were from the very beginning the flagship of its sustainable campus management.

This article is primarily a report of experiences from the perspective of a practitioner, who understands sustainable management as part of organizational development as well as transformative and social learning. The article closes with a discussion of success factors, which will outline the relevance of governance and participatory strategies (Bass et al. 1995; Disterheft 2011; Disterheft et al. 2015; Wanke 2014).

2 The Freie Universität's Energy Balance, 2000–2014

From 2001 to 2011, the Freie Universität Berlin—with a generally stable floor space—reduced its annual energy consumption by about 26 % or 42 million kilowatt-hours (kWh). After a few years of ups and downs the consumption level from 2011 was nearly achieved again in 2014. This is equivalent to €3.8 million in annual budget savings and a CO_2 reduction of 31 % from 2001, excluding area growth. Including the procured CO_2-free quality of electricity since 2010, the university's CO_2-emissions, caused by its energy consumption, were reduced by nearly 75 %. With this development, the university not only made a meaningful contribution to climate change mitigation, but also demonstrated the significant latitude that public institutions have in the area of energy efficiency.

The importance of energy use for the Freie Universität can be summarized as follows: in 2014, the FU's roughly 200 buildings comprised a square footage of 530,000 m^2 and used 123.8 million kilowatt hours (kWh) of energy for heat and electricity. In 2014, the university spent roughly €13.4 million on energy, of which more than 60 % (€8.1 million) was for electricity. The importance of energy consumption for the university's budget has risen sharply in the past few years, caused by the significant price increase in almost all energy sources (see Fig. 1).

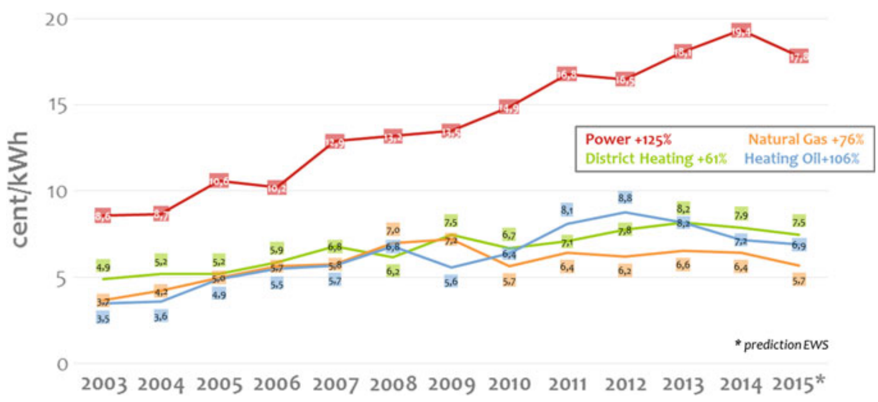


Fig. 1 Energy price development at the Freie Universität Berlin 2003–2015, cent/kWh, data retrieved from energy database of FUB 2016

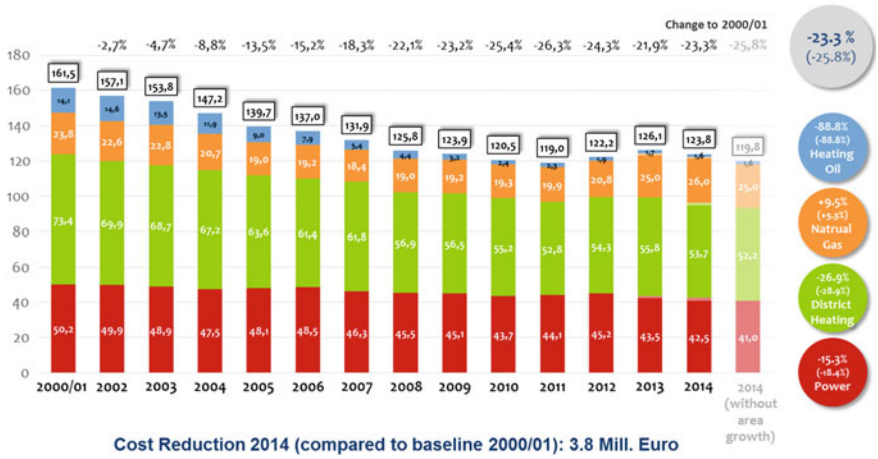


Fig. 2 Energy procurement at the Freie Universität Berlin 2000–2014 in MWh, heat adjusted for weather conditions, data retrieved from energy database of FUB, 2016

Without the efficiency strategy, the university would have spent €17.2 million on energy in 2014, that is an annual cost reduction of €3.8 million.

The cost argument is therefore the first key factor of the energy efficiency strategy adopted in 2001. This, combined with political crises in Berlin in the 1990s and 2000s following the German reunification that led to significant budget cuts for the university, are two of the most important reasons why the university management decided to invest heavily in this area. The price developments shown in Fig. 1 also make clear that this decision took place at a time when cost pressures—at the time still more closely temporally related to the liberalization of the electricity market—were more restrained (Wanke 2014).

A look at the university's energy balance (Fig. 2) reveals a decline in energy consumption every year from 2001 to 2011. The year 2012 was the first where energy use did not drop further, but instead grew until 2014 with little fluctuations (by 4 % including area growth, or 0.7 % without area growth). This increase can be interpreted as evidence that current efficiency measures have reached a point of diminishing returns; further reductions will thus be smaller and more difficult to achieve. Therefore, additional measures have to be tested and the instrument mix to be re-balanced.

A look at the development of individual energy sources shows clear structural effects. The use of heating oil, which is especially relevant from a climate perspective, was reduced through a concerted effort to transition to natural gas or district heating showing steady reductions from 14.1 million kWh (2000/2001) to 1.6 million kWh (2014). This reflects an overall reduction of 89 % (Fig. 2).

Heating use was reduced by nearly one-third from 2001 to 2014. The procurement of electricity is therefore "only" reduced by 15 %. It is important to note the increase in IT facilities and the subsequent need for ventilation and air-conditioning as well as the increase in energy-intensive equipment in building furnishings and natural science laboratories, which cancelled out the savings from the energy-efficiency program to some extent. This increase in energy use from labs and IT is expected to continue, due to electricity-intensive technological developments (e.g., autoclaves, centrifuges, lasers, MRI scanners, and the increased importance of IT), and accompanies the acquisition of new professorships.

Counteracting these trends will be at the center of future university sustainability management. Before discussing the key instruments of sustainable campus management, it is important to firstly point out the particular role of participatory approaches.

3 Sustainable Campus Management and Participation

While campus management doesn't count on the core tasks of a higher education organization, it plays an important role in the credibility and self-perception of universities. Through these activities, universities—as sustainability pioneers and living labs—can demonstrate the applicability and feasibility of their academic findings.

Universities are obviously very important academic and educational institutions with a great deal of human intellectual potential existing in them. However, as one of the organizational obstacles they face their highly differentiated and segmented structure. Sustainability, however, calls for continuous interaction and integration, one of the key questions being: how can we integrate a cross-sectional task like sustainability into a segmented structure? Projects that are based on a logistic approach, focused on the whole institution, in order to bridge the various disciplines and entities of higher education organizations, is one answer to this challenge. The second and third ones are a continuous dialogue with civil societal stakeholders and a continuous improvement process.

Sustainability management is a classic cross-cutting issue, which includes a broad range of faculties, entities and responsibilities. In order to integrate them, it is necessary for example to build relationships with key university actors and their most important stakeholders. For a university with roughly 40,000 university actors this means that communication and participatory strategies play a critical role. The needs for participatory approaches result particularly from the following factors:

- Due to their complexity, solving global problems requires systematic interdisciplinary scientific collaboration and a close transdisciplinary cooperation between scientists and civil societal stakeholders.
- The different dimensions and goals of sustainability—environmental, social, economic, and cultural—need to be integrated where possible.
- Sustainability management is a cross-sectional task, which requires continuous multi-level coordination

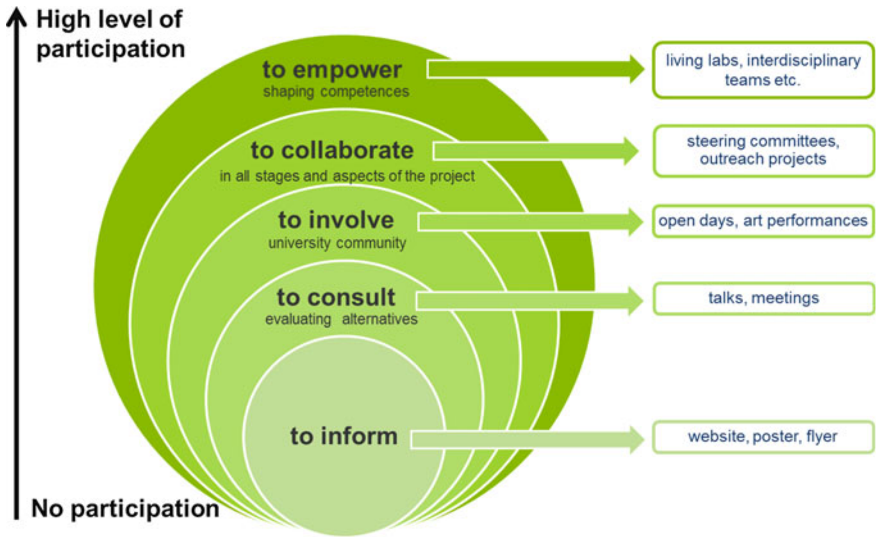


Fig. 3 Levels of participatory approaches, adapted from International Association for Public Participation (2007)

- aiming at a continuous involvement of internal stakeholders and entities
- balancing environmental, social, cultural and economic targets
- taking into account the different interests and perceptions of stakeholders
- encouraging behavioural change
- looking for systematic win-win situations
- making choices (trade-offs) between alternatives and conflicting targets

All these points demand participatory approaches (see Fig. 3), which aim to involve different disciplines, levels and entities of the university, to focuse on decision-making, empowerment and implementation processes and to foster living lab projects as well as a whole-institution approach. In sum, sustainable campus management should be viewed as part of organizational development as well as transformative and social learning—aiming to define new roles, competences, responsibilities, multi-level commitments and improvement processes.

The particular importance of participatory approaches are reflected, if you consider the instruments and activities Freie Universität has implemented since 2001. Most of them are based on successful participation processes. Only a few instruments could be classified as exceptionally technological or management-driven.

4 Instruments in a Chronological Order

This section describes the most important instruments of sustainable campus management at Freie Universität Berlin. The key instruments are listed subsequently in chronological order (Wanke 2014; FUB 2016) (Fig. 4):

2001 Establishment of an **energy and environmental management unit** as part of the facility management department. Foundation of a **steering committee**, led by the head of finance and administration. Members of the committee were the administration directors of the energy intensive faculties, the head of the facility management department, a representative of the staff council and the coordinator for energy and environmental management. The steering committee worked in this composition for the first 6 years, and then it was extended by all faculty directors. Due to the fact that sustainability management needs a more holistic and cross-cutting composition of the steering committee, it was replaced by a new sustainability steering committee in 2016, combined with different working groups.

2002 Step-by-step establishment of an **energy controlling system** by closing existing metering gaps, introducing an energy database and evaluating the energy consumption of the university buildings. Each building of Freie Universität is equipped with at least one electricity meter and one heating meter. The energy consumption of the bigger buildings and laboratory buildings are metered in a more differentiated way. The data are collected, analyzed and evaluated by an energy controlling system, which is in charge of the Unit for Sustainability and Energy Management. Simultaneously, energy audits in collaboration with external consultants were implemented.

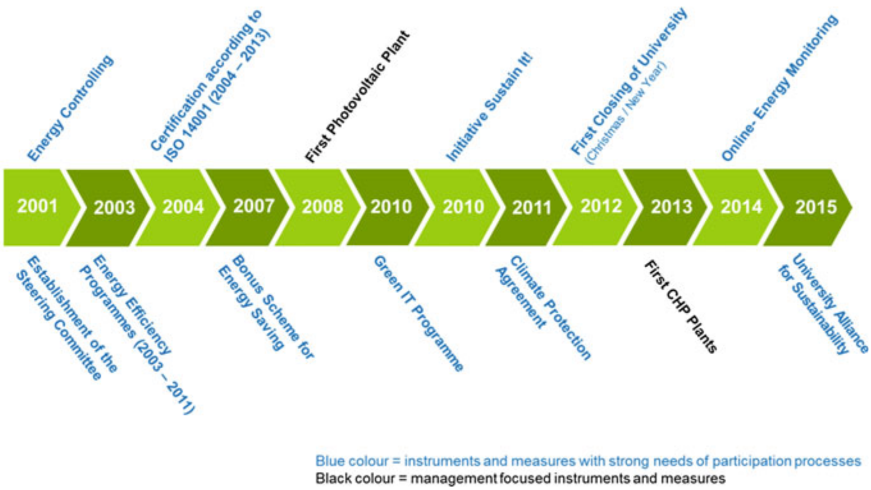


Fig. 4 Instruments of sustainable campus management in chronological order

In 2010 the university started the installation of an online system as testbed in a lab building. Since 2014 the university began to install remote readable online meters in almost all buildings. The whole university will be integrated in the online system in 2017.

2003 Implementation of the first **annual energy efficiency program**. The main focus of the programs was on energy saving measures in the engineering sector, especially the modernisation of heating and ventilation systems combined with updating ventilation and air-conditioning control technologies. These optimisation measures were combined with the insulation of flat roofs and upper story ceilings. In sum the university spent 1.2–2.5 million Euros annually until 2011 for the programs. The reductions in heating were between 15 and 50 %—averaged at 31 %. Many buildings saw reductions of 40 % or more. Today, 90 % of the university's building area is heated by modernised, energy-efficient heating systems. This sector had—according to findings from initial building analysis—comparatively high energy-saving potential with attractive payback times. The measures could thus be considered as win-win solutions. Building-based efficiency measures such as roof insulation were also integrated to some extent, which decreased return on capital, but within an economically attractive package of measures. These efforts were supplemented through organizational improvements such as shutting down central hot water supply or adapting operating times to actual use. Figure 5 shows chosen modernization measures along with key statistics related to three selected projects. All measures have reaped economic and environmental benefits above their initial cost to the university many times over and thus provide a significant contribution to the ecological modernization of the Freie Universität`s campus.

2004 Start of **environmental certification according to ISO 14001**, combined with the formation of environmental teams in all scientific departments. The certification process has several positive outcomes, particularly in the fields of communication, in-house training and in the system for authorized persons. However, it was stopped in 2013 due to a too strong focus on legal compliance aspects, as well as in order to get time resources for the establishment of a sustainability management system and to establish a new governance structure.

2007 After a phase of improvements involving the modernisation of the university buildings, technical improvements had to be supplemented by organizational and behaviour-focused energy savings. The university launched **the bonus system for energy conservation in 2007**, which enables the faculties to earn money by saving energy. The bonus scheme is based on a defined baseline consumption. The incentive program is structured as follows: departments and research faculties can earn an annual bonus from the central budget if energy use in their facilities is less than the

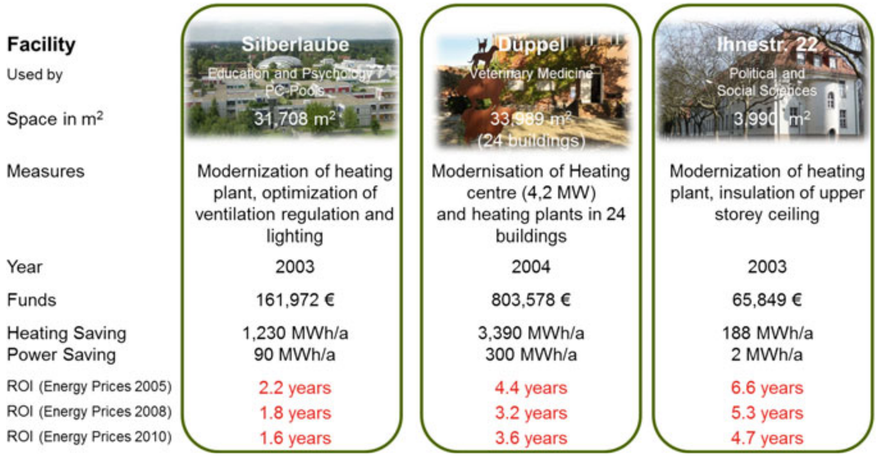


Fig. 5 Energy efficiency measures and key figures from selected projects, data retrieved from energy database of FUB, 2016

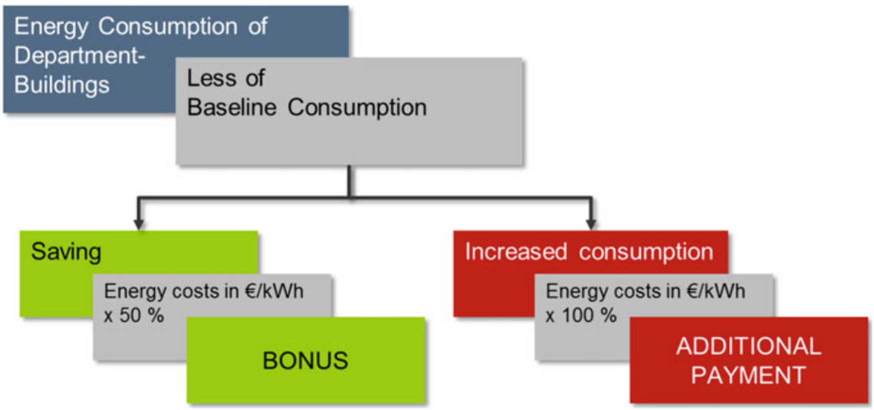


Fig. 6 Principles of the bonus scheme for energy conservation

previous year's baseline. The size of the bonus is half of that year's calculated cost savings. However, energy use above the baseline must be covered in full by the institute itself (see Fig. 6).A look at the results of the incentive program shows that almost all faculties earned bonuses in the last six years (see Fig. 7). Especially striking is the development in the energy-intensive scientific department of biology, chemistry and pharmacy, which had to pay a fine of €47,000 in the first year, but earned bonuses of up to €270,000 in subsequent years. The incentive scheme has been successful and enhanced energy-saving activities as well as instigating learning processes in the departments. Most took new or additional action

Department	Bonus 2007	Bonus 2008	Bonus 2009	Bonus 2010	Bonus 2011	Bonus 2012 (Baseline: -2%)	Bonus 2013*) (Baseline: -4%)
Biology, Chemistry, Pharmacy	-47,464 €	101,583 €	211,961 €	220.983 €	270,162 €	212,288 €	176,876 €
Physics	5,670 €	20,199 €	13,333 €	25.049 €	59,206 €	31,602 €	44,481 €
Political and Social Sciences	13,620 €	8,837 €	12,191 €	9.945 €	4,461 €	4,882 €	3,584 €
History / Cultural Studies	5,740 €	8,700 €	12,427 €	13.877 €	14,806 €	15,278 €	3,781 €
Business & Economics	4,058 €	7,070 €	8,144 €	8,736 €	11,765 €	11,575 €	9,304 €
Laws	1,412 €	6,597 €	14.138 €	13,505 €	6,602 €	7,940 €	7,115 €
Philosophy & Humanisties	4,345 €	5,522 €	4.513 €	7,079 €	16,328 €	11,410 €	6,581 €
Education & Psychology	-5,918 €	2,601 €	5.837 €	5,452 €	8,218 €	2,495 €	1,141 €
Mathematics & Computer Sciences	-2,553 €	2,591 €	5.419 €	4,609 €	4,107 €	3,187 €	5,486 €
Earth Sciences	5,909 €	1,537 €	4.451 €	4,307 €	4,573 €	536 €	k.A.
ZI East European Studies	1,994 €	3,141 €	4.498 €	3,498 €	1,684 €	2,234 €	2,313 €
ZI Latin Anmerican Studies	361 €	1,179 €	971 €	764 €	1,365 €	1,482 €	738 €
ZI John F.- Kennedy Institute	486 €	0 €	0 €	684 €	247 €	883 €	- 629 €

Fig. 7 Monetary results of the energy saving incentive program, 2007–2013, data retrieved from energy database, FUB 2016

to reduce their energy use, such as by naming energy representatives, engaging caretakers in energy-efficiency measures, or regularly communicating energy-saving tips. Some institutes used part of their bonus to fund further energy-efficiency measures such as exchange programs for old monitors and inefficient refrigerators. At the same time, building audits continued to show additional energy-saving potential in behavioral areas. In order to increase motivation in the scientific departments, university leadership decided to reduce the baseline an additional 2 % annually in 2012 and 2013, and 3 % in 2014 and 2015.

2008 Since 2008, the Freie Universität has leased the roof space of several buildings for **photovoltaic (PV) plants**. Long-term use contracts were signed with various investors based on the German Renewable Act. Electricity generated by the solar PV plants is fed into the electricity network of the Freie Universität, in agreement with the local electricity grid operator. Of particular interest is one PV plant, which entered operation in 2009 and was financed by the student initiative UniSolar. At the end of 2013, installed PV units had a combined capacity of 676 kW, able to generate 600,000 kWh of clean electricity annually.

2010 Foundation of the **sustainability initiative Sustain It!**, which was created by students, the Environmental Policy Research Centre (FFU) and the Unit for Sustainability and Energy Management. The various events held by this initiative, from sustainability campus days, a lecture series “From knowledge to action," to various project courses and urban gardening activities have increased visibility for sustainability issues and play an important role in stimulating dialogue within the university and with external stakeholders. Launch of a **Green IT programme**, which aims to reduce IT-related power consumption. An effective IT system is one of the most important infrastructure requirements for successful research, teaching, and administration. IT development requires not only substantial financial resources for procurement but also entails rising operational costs for IT use and related cooling. Electricity use at the Freie Universität's main computing center, ZEDAT, increased by a factor of 3.4 from 2003 to 2012. Electricity costs for ZEDAT during this time more than quadrupled. This development is typical for the fast-growing IT sector and affects virtually all IT-intensive institutions. In order to combat this trend, the university launched a special project for Green IT in 2009 that included a comprehensive survey of IT structures and technology.In 2010, the university created an IT action plan based on this survey, which included efficiency measures for all IT-related areas, from structural changes in procurement and accelerated centralization of servers to adjustments in power and data management.

2011 **Commitment on a joint Climate Protection Agreement** with the state of Berlin, defining measures, which aimed to reduce the university's energy consumption by a further ten percent until 2015, and to realize sustainability measures in the teaching and outreach sector.

2012 First university **closing for a period of two weeks** during the academic holidays between Christmas and New Year. In this time the temperature in the university buildings—except buildings with animals and plants—are reduced to a level of 12–14 °C. The measure aims to improve both work efficiency and energy conservation. The closing procedures are based on a close collaboration between operational staff, caretakers and external cleaning services. Meanwhile the closing days are also used for additional energy audits. The annual financial outcomes of the closing periods were between €320,000 and €360,000.

2013 Installation of the first two combined heating and power plants with an overall capacity of 520 kW_{el}. Today four CHP plants with a capacity of 710 kW are working, which make with an annual generation of ca. 4.5 million kWh a relevant contribution to substitute more than 10 % of the former electricity procurement, simultaneously reducing CO_2-emissions. One CHP-plant, located in the Botanical Garden, is based on biogas.

2014 Launch of an **online energy monitoring system**: Energy monitoring and controlling are among the most important prerequisites for a successful operational energy management based on reliable analysis and the optimization strategies developed from this. The construction of an energy database and collection of critical data became the first major task of the energy and environmental unit when it was created in 2001. Since then, heat and electricity usage have been monitored at least at the building level. Until 2014, meters were read at least monthly by operations personnel, except in one pilot property. Since then, the university has begun a project to establish a university-wide online monitoring system. This should be completed by the end of 2016.The significantly improved analytical capacity of an online system, along with targeted team and communications work, should enable the university's energy use to be reduced by at least an additional 5–10 %.Generating optimisation possibilities will be successful, if the online monitoring is not only comprehended as a controlling tool but also as a communication and participatory tool, involving the faculty administration heads of the faculties, operational staff, caretakers, IT staff and students, as well as academics. The latter are responsible for setting the needs of ventilation or the procurement and operation of IT and lab equipment.

2014 Freie Universität becomes a member of three **international sustainability networks**: the International Sustainable Campus Network (ISCN), the UNICA Green Network and the Green Alliance for Sustainable Future (GAUSF), founded by the Peking University.

2015 In 2014 the executive board of the Freie Universität had already decided to build a more **comprehensive sustainability management**, which includes the establishment of a new steering committee, a more centralized coordination office and the drafting of a sustainability report as next steps. The former energy and environmental management unit is now assigned directly to the executive board and is reconceived in the more comprehensive discourse of sustainability and updated accordingly. Academic teaching and inter- and transdisciplinary educational approaches for sustainable development are moving to the fore.Together with its four strategic partner universities (University of British Columbia, Canada; Hebrew University of Jerusalem, Israel, St. Petersburg State University, Russiy and Peking University, China), Freie Universität founds the **University Alliance for Sustainability**. The universities' network aims to intensify the partners' efforts in researching, teaching, and managing sustainable campuses, to exchange good practice and create a network of both established and emerging researchers and practitioners in various fields of sustainability that spans disciplies, institutions and entities. The so-called 'whole institution approach' is the guiding principle of the international network, which is funded by the German Academic Exchange Service (DAAD). The project runs until 2018. Its key instruments are a mobility program for senior researchers, junior researchers, students and administrative staff, as well as annual conferences including management and teaching incubators.

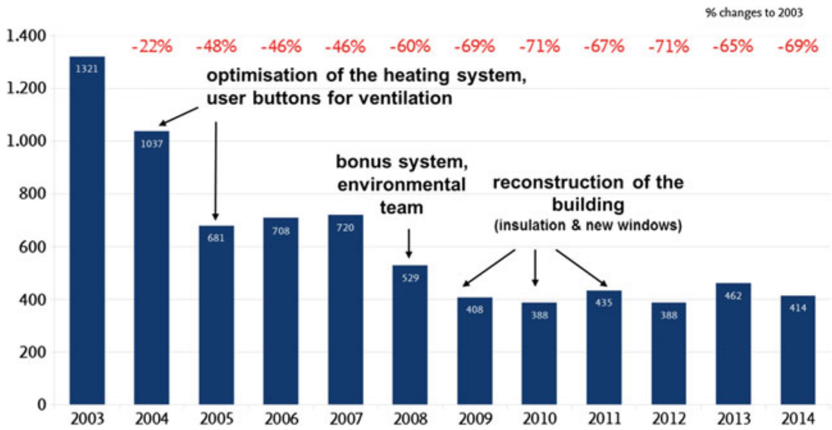


Fig. 8 Heating use change in the main building of scientific department of laws, data provided by energy databank of FUB 2016

A few buildings at Freie Universität allow a differentiated view on the outcomes of the implemented measures, caused by technological, organizational, and building improvements. The main building of laws, for instance, has seen a heating reduction of 70 % since 2003. The modernization of the heating and ventilation systems cut the building's heat requirements in half in 2004 and 2005. Purely organizational measures—namely the building of the environmental team in combination with the bous scheme—reduced the building's energy use in 2008/09 by an additional quarter. Renovations of the building's envelope reduced energy usage to the 40–45 kWh/m^2 (see Fig. 8). This building is therefore an example of the potential of energy-efficient building renovations and shows the important role of organizational measures.

Taking all instruments together, it is important to keep in mind that—with exception of only three instruments—all these activities are connected to participatory approaches and team building processes. For example, the path to ISO 14001[1] environmental certification—begun in 2004—includes the establishment of 11 decentralised environmental teams. The members of a steering group, created in 2002, and the roughly 120 members of the interdepartmental environmental team represent the key social infrastructure of sustainable campus management and are the base for transformational and social learning processes. The implementation of the annual energy efficiency programs were not possible without the systematic involvement of the operational staff and the building users. Similarly, the

[1]The international environmental management standard DIN EN ISO 14001 defines internationally valid requirements for environmental management systems and belongs to the group of standards developed by the International Organization for Standardization (ISO).

implementation of the Green IT program, particularly the optimization of power management as well as the modernization of IT procurement, was only possible in teams working between different administration entities of the university. Last but not least, the energy controlling system can only generate successful outcomes if it is used as a communication instrument by involving different internal stakeholders. The effectiveness of international networks essentially results from the active participation of their members.

5 Success Factors and Conclusions

The Freie Universität has demonstrated with the outlined activities that public institutions are in a position to reduce their energy use significantly and reap economic benefits through their own actions.

The university has also shown that energy efficiency, which has long been a relatively underrepresented aspect of the energy policy in German, has meaningful potential. Before discussing the key success factors, it is important to realize that energy efficiency measures, such as those implemented here, are subject to very specific—and often restrictive—particularities (e.g. German Bundestag 2015, document 18/6782). These include:

- heterogeneous building structures and installed technical systems
- the small-scale nature of many energy-efficiency measures (both technically and organizationally)
- lack of visibility for success stories
- below-average interest in technical measures
- high communication requirements
- systematic interdependencies between technical, organizational and behavioral measures

How has the Freie Universität managed to develop and implement an energy efficiency strategy despite the restrictions listed above? What are the most important success factors from the perspective of the practitioners who managed this process?

Large parts of the answer can be found in the first motifs as well as in the instruments listed above and particularly in the quality of their implementation. The quality of every single project is a general success factor. It is also obvious that the continuous modernization of infrastructural sectors plays an important role in sustainability management. Technical and economic aspects or feasibility questions are often highlighted in studies and internal discussions. These insights are not really surprising, but sustainability strategies should pay particular attention to these factors, especially in the early phase.

5.1 Cost Arguments, Experience of Crises and Institutional Modernization

Looking into success factors raises the issue of key motives. The cost argument was mentioned above as an important initial motive. The university's energy costs are only a bit more than 3 % of the total budget. However, they are seen by university's top management as comparatively variable and open to influence. Crises in the 1990s and 2000s caused by budget cuts and political uncertainty after German reunification related to future budget planning played a critical background role here.

It is also important to note that cost arguments for a university need to be related to other claims. Nonmonetary motives, such as raising the university's profile as an institution with a holistic sustainability orientation that goes beyond research and teaching to include the university's own actions, gained meaning and played an important complementary role. These motives were relevant both within the university and externally from the beginning (Wanke 2014).

Another important motivation was a separation from the contract model. As early as the 1990s, the Freie Universität gained experience with external contracting models and determined that traditional money-saving measures had more impact when implemented under the university's own responsibility. Internal implementation has the benefit of keeping cost savings within the institution and building in-house competencies. Beyond this, regulation costs can be reduced or constructed more pragmatically than would be possible with external solutions. Internal implementation does not mean, however, forgoing external expertise. The Freie Universität has worked together with specialized engineering offices on its annual energy-efficiency programs and contracted building analysis and planning of concrete measures with them. These cooperations can be considered an important success factor.

5.2 The Role of Leadership

Sustainability management is a classic cross-cutting task, whose goals must be integrated into decision-making and daily routines of various line functions. Resulting goal and competence conflicts are best resolved when top management is informed and supporting it. This observation is true in all phases, but particularly decisive for overcoming problems in the start-up phase. University leadership filled this role in early years through its active and decisive role in the energy and environment steering group created in 2002, but also through strategic decisions such as the introduction of environmental certification based on ISO 14001 (2004), introduction of the incentive system for energy savings (2007) and establishment of the Green IT program (2010).

5.3 Integration of Infrastructural Aspects

The cooperation with building, facility, and IT decision-making processes was shown in early years to have clear benefits. Technical and building infrastructure decisions have a particularly long-term character and because of this were seen as important from the beginning. In order to link decisions to the allocation of financial resources and ensure that building processes took into account the complex constellation of regulatory requirements, a close cooperation with building and facilities management was necessary. How to structure this cooperation, however—whether through procedural agreements or clear organizational integration—has no simple answer. The importance of building measures in the energy-efficiency program's early stages made integration with the energy and environment unit the obvious choice. This facilitated close involvement in building-related decision-making processes and strengthened the unit's initiating function. However, a restrictive side effect was that the unit's activities were seen by university actors as primarily technical and part of facility management.

5.4 Different Participatory Approaches

Sustainability management is not only a leadership responsibility but requires the acceptance and cooperation of everyone involved at the university. This is true for almost all key instruments, the implemented technical measures, the bonus system for energy conservation, as well as the full spectrum of organizational and behavioral energy-efficiency potentials. Being broadly embedded into the university organization through participatory measures is critical. At FUB, this was accomplished at the leadership level through the creation of the steering committee and the establishment of decentralized energy and environmental teams as part of the ISO 14001 process and creation of targeted communications efforts. In addition, the sustainability initiative Sustain It! has taken on a valuable trend-setter role on these issues. The positive outcomes of participatory processes mainly concerned the social engagement for sustainability at different levels and entities. That is a crucial factor for almost all other instruments and action programs. The outcomes can be described as follows:

- enhanced understanding of sustainability issues and demands
- improved collaboration and networks of individuals and entities
- reliable consensus on key issues, responsibilities, institutional roles and actions
- strengthened commitments of top and middle management for sustainability targets.

5.5 Instrument Mix and Holistic Perspective

In presenting the individual activities it has become clear that sustainable campus management needs to include technical, organizational and behavioral components. These should be reflected in a diverse selection of instruments and a holistic perspective that takes these various components into account. Technical and building measures are most successful when implementation is complemented by a communication strategy that engages different stakeholders. On the other hand, it is impossible to expect the university community to engage in energy-saving behaviors when buildings are in an antiquated state or cannot be adapted to meet users' needs. The success of the energy-efficiency incentive system established in 2007 is based in large part on this principle.

5.6 Conclusions

In summary, during the last 15 years at Freie Universität it has become significantly clearer that governance factors and participatory strategies are having a strong influence on the success of sustainability management on campus. Some of the implemented instruments, for instance the bonus scheme, parts of the annual energy efficiency programs, the certification of the environmental management system, and closing the university during the academic holidays can generally transferred to other universities. However, even if not each single instrument is transferable to other universities, the structural factors such as the above listed governance aspects and the realized modus of participation (cross sectional teams) can be relevant for other universities all over the world.

What is meant by this? Sustainability management requires more than classical management instruments, such as controlling and evaluation tools or the initiating of technical and infrastructural improvements. It is just as important to have the clear, strong and resilient commitment of the top management as it is to have an authentic collaboration with the most relevant management levels and entities. Therefore, it is crucial to involve the stakeholders, having a key role, systematically, to embed the processes as widely as possible within the organization both by forming relevant teams and establishing a proactive orientation. Participatory approaches assume a leading role, due to the cross sectional character of sustainability management and the segmented organization of universities. Operational qestions as how to select the right team members, how to empower them with the needed team skills, how to choose the suitable participatory methods, how to define the professional tasks and social roles of the team members as well as how to synchronize them with the key organization of the university play then a more relevant role.

In effect, universities should pay more attention to these aspects, which can be seen as part of organizational and personnel development. However, there are a lot of open scientific and qualitative questions in these areas which are based on a micro-level approach. Practitioners have to find answers to these questions in their daily work. Against this background, it is certainly a good idea to integrate them systematically in future research projects which can be organized as living labs.

Literature

Bass, S., Dala-Clayton, D. B., & Pretty, J. (1995). Participation in strategies for sustainable development. Environmental planning Issues No. 7, London.

Bertelsmann. S., & Staatsminsisterium, B.-W. (Ed.) (2014): Partizipation im Wandel. Unsere Demokratie zwischen Wählen, Mitmachen und Entscheiden, ISBN 978-3-86793-588-3, Kernergebnisse in https://beteiligungsportal.baden-wuerttemberg.de/fileadmin/redaktion/dateien/PDF/140905_Demokratie-Studie.pdf

Deutscher, B., Drucksache 18/6872 (2015). Energieeffizienzstrategie Gebäude. Wege zu einem klimaneutralen Gebäudebestand, 76 p, 19 Nov 2015.

Disterheft, A. (2011). Sustainability at the campus. Environmental Management Systems (EMS) implementation processes and practices at European Higher Education Institutions. Top-down versus Participatory Approaches, Universidade Aberta, May 2011.

Disterheft, A., Azeiteiro, U. S., Filho, W. L., & Caeiro, S. (2015). Participatory processes in sustainable universities—what to assess? *International Journal of Sustainability in Higher Education*, *16*(5), 748–771.

Freie Universität Berlin (FUB). (2016). Website and energy database, provided by the unit for sustainability and energy management (www.fu-berlin.de/nachhaltigkeit).

Heinrich-Böll-Stiftung (Hrsg). (2014). Experiment Bürbgerbeteiligung. Das Beispiel Baden-Württemberg, Berlin. ISBN: 978-3-86928-104-9.

International Association for Public Participation. (2007). Spectrum of public participation. Last access 21 Mar 2016. http://www.iap2.org/associations/4748/files/IAP2%20Spectrum_vertical.pdf

Lambrechts, W. (2015). The contribution of sustainability assessment to policy development in higher education. *Assessment & Evaluation in Higher Education, 40*(6), 801–816.

Robinson, J., Burch, S., Talwar, S., O'Shea, M., & Walsh, M. (2011). Envisioning sustainability: Recent progress in the use of participatory backcasting approaches for sustainability research. *Technological Forecasting & Social Change*, *78*, 756–768.

Schneidewind, U., & Singer-Brodowski (2014). Transformative Wissenschaft. Klimawandel im deutschen Wissenschafts- und Hochschulsystem, ISBN 978-3-7316-1057-1.

UNESCO. (2009). Communique 8th July 2009, World Conference on Higher Education: The New Dynamics of Higher Education and Research For Societal Change and Development, (UNESCO, Paris, 5–8 July 2009).

UNESCO. (2010). Universities for sustainable development. Declaration by the German Rectors' Conference and the German, Commission for UNESCO on Higher Education for Sustainable Development, Resolution by the Executive Committee of the German, Commission for UNESCO on 22 January 2010.

Waltner, C. (2012). Sustained energy efficiency efforts pay major dividends for Freie Universität, Interview mit Andreas Wanke. in: www.smartconnectedcommunities.org

Wanke, A., & Trenz, S. (2001). *Energie management für mittelständische Unternehmen*. Rationeller Energieeinsatz in der Praxis: Köln.

Wanke, A. (2006). Technische und organisatorische Modernisierung als gemeinsame Herausforderung. Energiemanagement an der Freien Universität Berlin, in Jürgen Pöschk (Hrsg.): Energieeffizienz in Gebäuden, Jahrbuch 2006, Berlin.

Wanke, A. (2007). Wer sparen will, muss investieren. Energiemanagement an der Freien Universität Berlin; In Freie Universität Berlin (Hrsg.): Wissenschaftsmagazin fundiert, Themenheft Energie (pp. 86–89).

Wanke, A. (2014). Nachhaltiges Campus-Management an der Freien Universität Berlin. In A. Brunnengräber & M. R. Di Nucci (Hrsg.), *Im Hürdenlauf zur Energiewende* (pp. 309–329). Springer Fachmedien, Wiesbaden.

Wouters, M., Hardie-Boys, N., & Wilson, C. (2011). Evaluating public input in National Park Management Plan reviews. Facilitators and barriers to meaningful participation in statutory processes. In: Science for conservation 308. Publishing Team, Department of Conservation, Wellington, New Zealand, May 2011, S. 17, last downloaded on June 17, 2014 (PDF 415 kB, ISBN 978-0-478-14872-5).

Author Biography

Andreas Wanke born in 1961, worked from 1990 to 2001 as a political scientist at the Environmental Research Centre (Forschungszentrum für Umweltpolitik) at the Department of Political and Social Sciences of Freie Universität Berlin focusing on consultation projects in the field of energy and environmental management. Since 2001 he has been in charge of the coordination of the energy and environmental management in the university administration. Today he is the director of the Sustainability and Energy Unit, which implements the university´s commitment to sustainability and energy efficiency by developing and steering different instruments as well as activities and by offering corresponding services in the field of coordination and consultancy. The unit is assigned directly to the executive board of Freie Universität Berlin.

Education for Sustainability: A Wisdom Model

Lorraine Lander

Abstract

Educating students to become more sustainable in thinking and behaviors, both at a personal level and in their professional careers, is an important contribution to moving the planet toward more sustainable development. The lack of a strong theoretical framework which would unite education for sustainability across academic fields and allow for long-term and big picture planning, however, is a weakness. This paper proposes a new model to guide education for sustainability based on the concept of wisdom. Benefits of this model include connecting educators to a range of existing education and developmental theories connected to its four main components. The model also provides for organization of approaches to sustainability education across disciplines, supports curricular design, and assessment. It can be applied at levels from lesson through course and degrees, as well as across years of education. In fact, a review of wisdom theory further supports that sustainability thinking and actions can be considered wisdom in action. One important implication of implementing this model is that good quality education for sustainability will also encourage the development of wisdom. The paper will be of interest to anyone connected to education for sustainability.

Keywords

Education · Wisdom · Curriculum design · Thinking · Ethical reasoning · Assessment

L. Lander (✉)
State University of New York-Empire State College, 25 North Street,
Canandaigua, NY 14424, USA
e-mail: lorraine.lander@esc.edu

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_3

1 Introduction

Sustainable and sustainability, the terms seem to be everywhere. A multitude of questions arise when considering their meaning and application to how humans live. The idea of sustainability, that humans need to consider others, plan for future generations, and take better care of the planet, has become more prominent since the work of the Brundtland Commission (United Nations Commission 1987). Enacting more sustainable behaviors will require better understanding of the various environments which humans inhabit and will be a task taking extensive effort, coordination, and energy.

Educators, particularly those working in higher education, are charged with preparing the sustainability leaders of tomorrow (Cortese 2003; Sibbell 2009; Stephens et al. 2008), yet are challenged with finding ways to educate about what sustainability means and how to practice it (Jones et al. 2010; Shephard 2010; Moore 2005). The purpose of this paper is to propose that the concept of wisdom, which has not previously been connected to education for sustainability (EfS), can inform and strengthen those efforts given the significant overlap in cognitive processes and ethical understandings that underline both concepts. Further, an analysis focused on components of wisdom will support that sustainable behaviors can be considered a subset of wisdom in action.

2 Sustainable Development, Sustainability, and Wisdom

A fuller understanding of connections between sustainability and wisdom requires consideration of how sustainability has been defined. For example, the Brundtland Commission's definition of sustainability (actually a definition of sustainable development; United Nations Commission 1987) considers how to meet the needs of future generations without impinging on the needs of the present population, but does little to guide changes that are necessary within individuals and groups. The focus of this definition on the outcome of sustainable development, rather than on the types of thinking, understanding, and actions that are needed to reach that state, is a serious weakness.

While the Brundtland Commission focused on the outcome of sustainable development, other sustainability definitions have considered contexts such as nature and various social contexts such as financial and cultural. For example, UNESCO (UN 2005a) proposed that sustainable development included environmental protection, social development, economic development and cultural development. Fien (2004) proposed four aspects of sustainability that include social, economic, political, and biophysical systems. The popular concept in business of the triple bottom line (Elkington 1997; Slaper and Hall 2011), including people, planet, and profit, is also about contexts. These contextual approaches to understanding sustainability do little to suggest how to educate students to be more sustainable in their thinking and actions.

A definition of sustainability that focuses on the internal cognitive and affective processes that are necessary for sustainability thinking and actions, however, could provide guidance for educating students who would contribute to sustainable development. For example, Lander (2015) proposed that sustainability is a way of thinking and decision making that is based on ethical principles and which supports the welfare of social and natural environments now and in the future. This definition is context free and has broad applicability across both social and natural environments which can vary greatly around the planet. Defining sustainability in terms of cognitive and affective processes provides a foundation for identifying specific learning goals for EfS, such as increased complexity in thinking skills and decision making, improved ethical reasoning, as well as better understanding of social and natural environments through systems thinking. When sustainable living is defined by the necessary internal mental processes that it requires, it becomes clear that a more explicit focus on these internal processes would benefit EfS.

3 Wisdom as an Organizing Concept for Education for Sustainability

Wisdom has been proposed as beneficial to sustainable living (Orr 2002; Rhodes 2007; Sterling 2003) when it is considered to be high levels of complex thinking and successful participation in society. Yet only Sterling (2003) wrote extensively on the topic, proposing that wisdom related to sustainability is primarily about doing. He equated wisdom with 'whole systems thinking' (p. 52) and proposed a systemic wisdom that comes from more complex understanding and engagement with phenomena related to the various environments that humans inhabit (social, political, environment, natural world, etc.). He uses the term 'engaged participation' (p. 52) to explain how systemic wisdom goes beyond ecological literacy and is about more than cognition, but must include perceptions, emotions, and taking responsibility for the consequences of personal attitudes and actions. While there is overlap of the model proposed below with Sterling's writings, this paper extends that work and provides more explicit details on how students need to think and act to come to possess systemic wisdom (wisdom for systems).

Wisdom is a complex and multifaceted construct and there is no agreed upon definition, although most conceptions have significant overlap. Yang (2008) categorized definitions of wisdom into four groups including those that consider it as personality characteristics and competence (Ardelt Ardelt 2004; Clayton and Birren 1980), a result of positive human development (Erickson 1959; Labouvie-Vief 1990; Meacham 1990), a system of practical knowledge (Baltes and Staudinger 1990), and a process observed in real world situations (Sternberg 1998; Yang 2008). In a review article Bangen and colleagues (2013) found five components consistently represented including: pragmatic life knowledge, prosocial attitudes and behaviors, awareness of self and others, coping with uncertainty, as well as emotional regulation and self-control.

The proposed model of wisdom, which would be more easily applied to education for sustainability, has four components or 'pillars' including knowledge, thinking, ethical reasoning, and action for social good (Lander 2009) (See Fig. 1 for a graphic of the Four Pillar Model of Wisdom. Table 1, contains a comparison of the proposed model with several major models of wisdom).

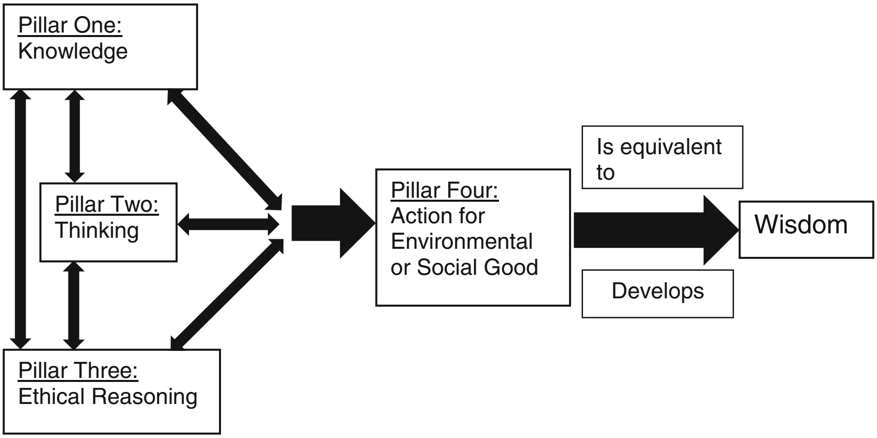


Fig. 1 Four pillar model of wisdom

Table 1 Comparison of how the four pillar model of wisdom differs from existing models of wisdom

Theorist(s)	Year	Main points of these conceptions of wisdom
Sinnott	1998	Postformal logic: primarily cognitive (not affective), systematic thinking, complex reasoning, high levels are paradigmatic
Sternberg	1998	Tacit knowledge, practical intelligence, contextual awareness, balancing interest and common good
Baltes (and Staudinger)	1993	Factual knowledge, procedural knowledge, life-span contextualism, relativism of values, recognition/management of uncertainty
Lombardo	2011	Knowledge, skills, and ethical understanding
Bangen et al., (review of wisdom)	2013	Common factors include: pragmatic life knowledge, prosocial attitudes/behaviors, reflection and awareness of self/others, coping with uncertainty, emotional regulation/self-control
Bassett	2011, 2015	Discernment/objectivity/holistic thinking, respect, fairness/justice, self-transcendence, tolerance for ambiguity and paradox
Yang	2008	Integration of conflicting systems, action based on this integrated thought with goal of positive effects
Lander	2006, 2015	**Proposed model**: knowledge, critical thinking, ethical reasoning, prosocial engagement

Pillar One The first of the pillars represents knowledge. Knowledge acquisition is at the heart of EfS. A large portion of those teaching efforts (Stirling 2003, 2004; Warburton 2003) helps students understand various environments and the systems that operate within them. An important secondary focus on knowledge and EfS considers information on issues and multiple perspectives (Wals 2007).

Pillar Two The second proposed pillar of wisdom is about thinking, defined as systematic and disciplined use of knowledge. Critical thinking is important, but other types of thinking may also be needed for sustainability including systems thinking, collaborative thinking, creative thinking, liminal thinking, and others (Lander 2015). Interdisciplinary thinking is essential to understanding and solving problems related to sustainability (Jones et al. 2010; Moore 2005; Warburton 2003). Integration of information across disciplines may be one especially important type of thinking related to EfS given the frequency of place-based education and problem-focused, as well as applied projects in EfS (Moore 2005; Steinemann 2003; Thomas 2009). Integration is also a core feature of wisdom according to Orwell and Achenbaum (1993) with Kramer (2000) suggesting that wise people can integrate extremes and think dialectically. Several other wisdom theorists (Bassett 2006, 2011, 2015; Clayton and Birren 1980; Kramer 1990; Yang 2001, 2008) propose that the ability to integrate cognitive and affective processes with the motivation to act is a core feature of wisdom.

Pillar Three Values and ethical reasoning, the third pillar, are foundational to most views of wisdom. This pillar is primarily concerned with how consideration of others interacts with knowledge, thinking, and prosocial action (the fourth pillar, see below). In fact, it is the balancing of competing interests that often draws an observer to label a decision or action as wise (Baltes and Staudinger 1990; Sternberg 1998). The ethical reasoning aspect of wisdom is one of the key pieces that connects it to the field of sustainability (Shephard 2008) given the strong association of social justice and concern for others and the planet that is expressed in sustainability understandings and in good quality EfS.

Pillar Four The fourth pillar of wisdom proposed here is prosocial decisions and action. While not present in all models of wisdom, it is an important feature of this model in that active decision making and behaviors guided by the components of the first three pillars must be carried out and enacted on (or a decision made to not act) to truly be considered wisdom and to form a relevant guiding principle for EfS.

The four pillar model of wisdom has advantages over other models of wisdom for educators interested in sustainability. While there is overlap of this model with aspects of others (see above), there are important differences that make this model more useable. First, it is more concise and uses concepts that connect with theories of learning and cognitive development. This model also has benefits over other models of wisdom due to its emphasis on values and ethical reasoning, which not all wisdom models specifically address. By targeting not just knowledge and the pursuit of expertise, but also encouraging students to development appropriate values and ethics of justice and caring, educators using this model of wisdom can do much to encourage sustainability. The final pillar, that of civic engagement and prosocial action, is also not always clearly stated in the other models of wisdom described below, yet it is fundamental to the kind of practical wisdom or wisdom in action that is connected to living sustainably. A comparison of the main features of these models of wisdom will help the reader see that they are not as easy to apply directly to aspects of education as the proposed model. How the four pillar model can specifically guide curriculum and be useful in practice will be discussed in more detail below.

4 Benefits of Aligning the Four Pillar Wisdom Model and Education for Sustainability

There are multiple advantages for EfS of adopting this four pillar model and its explicit focus on cognitive and affective processes related to ethical reasoning and action/decision making for social good. Benefits of the four pillar model include:

- Alignment with cognitive learning theory allows sustainability educators to draw on educational research about ways to promote knowledge acquisition, critical thinking and integration, values and ethical understanding, as well as, active and project-based learning.
- Theories and research connected to the four pillar components can help sustainability educators understand how to approach different age groups, including consideration of any relevant critical periods for openness to learning and change, ensuring that educational activities build on each other to move students from simple to more complex learning and understanding.
- Theories connected to the four pillars can provide structure for observations and data collection about the results of EfS, as well as providing a common language for organizing and discussing the results over a wide range of academic fields. Thus, for example, the results of EfS in art education might be more easily compared to the results of EfS in environmental education if theories about the development of thinking skills or ethical reasoning were a common thread uniting them.
- Professional development for educators about the topic of wisdom and how it develops for each of the suggested pillars would provide a structured approach to those efforts that can span all academic fields with much of the same information. It may also trigger development of wisdom for teaching among those instructors who learn more about it.
- Benefits for assessment of EfS become apparent if educators adopt goals related to the four pillars. For example, if one of the goals was increased ethical understanding, then educators could assess directly for that at the end of various programs. If a goal is encouragement of civic engagement, then assessment efforts could focus on whether that is taking place in programs, as well as

generalizing to students' involvement in home communities after they leave school.

- Research into EfS may benefit by organizing hypotheses and methods of study around the four pillars. For example, research into how to better address EfS with young children guided by this model could be broken down into considering how to work on knowledge acquisition, early development of critical thinking, age appropriate approaches to development of ethical reasoning and engagement in projects for a social benefit to others.
- Research into EfS could be reported not just as findings for that field, but also for their relationship to the educational theories associated with the pillars. So, for example, the academic body of general knowledge concerned with development of ethical reasoning could be informed by work on EfS, benefitting the broader field and grounding that work in a larger intellectual community.
- Organizing the field of EfS into these four pillars facilitates long term and large scale coordination across programs, years of education, different social groups, etc.
- Support for design and assessment for a range of educational levels from lessons through courses, programs, or the entire sequence of EfS in a student's educational career is also facilitated by considering the four pillars in this model.
- Theories on how wisdom develops may inform Efs. For example, Basset (2008, 2011, 2015) proposes several methods for developing wisdom, primarily focused on four components of her wisdom model. Discerning, a cognitive component, can be developed through deep understanding of causes, consequences, and relationships. Empathizing, an affective component, can be developed through awareness of multiple perspectives, compassion, and generosity. Engaging, an active component, can be developed through encouraging sound judgment, decision making, actions based on fairness, and moral courage. Being, a reflective component, can be developed through self-knowledge, self-acceptance, and self-transcendence. There is much overlap in these approaches and EfS, yet the fourth approach might be less common and could have value to consider. See Bassett (2011, 2015) for more details on specific suggestions on encouraging these in students.
- Research into teaching wisdom may also be helpful for Efs. For example, Trowbridge (2007) used reading, practicing character traits related to wisdom, and acting in real life settings in wise ways to foster it. Sternberg and colleagues (Sternberg et al. 2007) designed a successful program for wisdom instruction for middle school students focused on understanding multiple points of view and understanding the consequences to others of various actions.
- Both Baltes (1993) and Sternberg (1998) propose the importance of exposure to role models of wisdom in early years to support its development, suggesting role models may be useful in EfS.
- Focusing on EfS as a way of promoting development of wisdom helps establish a foundation for wise thinking and actions to develop. Erikson (1959) suggested that wisdom develops through practice in solving daily problems, supporting that problem solving can promote its development. With problem solving being

an important feature of both place-based and project-focused educational activities commonly used in EfS (Moore 2005; Steinemann 2003; Thomas 2009), as mentioned above, not only does sustainability thinking and behaviors get promoted in EfS, but development of wisdom may also be enhanced.

5 Application of the Four Pillar Model for Curriculum

The four pillar model can be used to analyze and evaluate specific sustainability curriculum from the level of lesson through course and even degrees. In the first example, a business and environmental sustainability certificate exists at a local public college. Four courses are part of this certificate including an introductory level course on environmental sustainability and three advanced courses focusing on ecological economics, ethics and ecology of business, as well as a capstone course on sustainability management. This program has overall learning outcomes, as well as more specific learning outcomes for each course. Using the four pillar model, these learning outcomes can be considered for the knowledge content, what thinking skills are being promoted (going even further, could consider how and in what ways integration of knowledge across the fields of environmental science, economics, and business will be accomplished), how ethical reasoning will be taught and practiced, and/or how the capstone will encourage active civic engagement and sustainability thinking that provides for the common good of businesses and the environments in which they operate. Going further, students could be assessed for entry level knowledge and/or skills and values that are pre-cursors to the learning goals for these courses. Rubrics could be designed for the four pillars and used for each of the courses or for the whole program. The certificate program could be evaluated for the temporal sequence of its learning goals, considering whether they move from simple to complex. Long term assessment could examine whether graduates who hold this certificate are continuing to manage using principles of sustainability (and wisdom) after completion of the certificate to see if the coursework has generalized beyond the classroom. These are just some examples of how the wisdom model can be applied to curricular design and evaluation in EfS.

In terms of critiquing major curricular approaches to EfS, this model may also be useful. For example, in business and sustainability studies, there is an emphasis on the Triple Bottom Line: people, planet, and profit (Elkington 1997). Yet, there is great tension between the pursuit of ‘profit’ in current economic models and sustainability (Jackson 2005, 2011). The Triple Bottom Line may also be in direct conflict with principles of sustainability such as “reduce, reuse, and recycle.” Using the proposed model of wisdom, particularly the third and fourth pillars, might help better align curriculum in business, if necessary, with the principles of ethical reasoning and action for the common good. Students in business courses and programs may then come to better understand the ethical issues related to promoting the sustainability of their businesses over the needs of people and the planet.

Another example of how this model may add to evaluating curricular design is to examine possible issues with environmental education as a substitute for sustainability education. While concern about the natural world is one primary issue in EfS, it is certainly not the only environment of consequence (Newport et al. 2003). For example, the extinction of various cultures around the world is an important issue (Soini and Birkeland 2014) that may not be part of environmental education. Unsustainable practices may be contributing to climate change and have serious implications for the habitability of large parts of the planet (McMichael et al. 2006; Sherwood and Huber 2010) or even trigger extinction of civilization itself (Gowdy 2007). Resolving priorities and reaching decisions related to preserving the natural world as well as human habitability of the planet involve important and intertwined issues that will require not just expertise in knowledge and thinking or even problem-solving, but ethical reasoning to fully understand and act in the best interests of all groups (human and other species) involved.

One last and useful benefit of aligning wisdom with EfS may be that wisdom has a wider appeal than the concept of sustainability. For example, one challenge in EfS can be resistance for a variety of reasons from time and funding through lack of interest and concern. The result of this minimizing and marginalizing can be a lack of interest by students, as well as insufficient support from other educators and administration. One way of overcoming this resistance may be to focus on wisdom, rather than simply sustainability alone. Wisdom has been of interest for centuries and its value is rarely questioned, thus it is hard to argue against focusing educational efforts on wisdom development which can at the same time also promote EfS and ultimately sustainable development. One drawback of aligning wisdom with EfS may be that it is not commonly on the mind of educators who see it as something that develops later in life. Communicating the importance of establishing a foundation for wisdom in earlier years would be important to overcome this bias.

6 Conclusion

The various sustainability challenges facing the natural and social worlds are complex. Adopting the view of sustainability thinking and actions as wisdom in action has many benefits for the field of EfS. The four pillar model of wisdom proposed in this essay can assist sustainability educators to target efforts to move students toward better understanding and ability to engage with sustainability issues and lead more sustainable lives by aligning their work with existing learning theories, activities, and methods of promoting the concepts associated with the four pillars, as well as how to integrate them by considering wisdom and its development and promotion.

Sustainable development requires expertise, based not just on knowledge, but also complex thinking skills. Knowledge and thinking are common elements of education, but may be insufficient for either EfS or wisdom development. As much as expertise is not sufficient for wisdom, EfS will not be sufficient without including a strong focus on ethical understanding and values based on considerations of how morals develop and inclusion of character education. As well, sustainability educators must encourage their students to be active inhabitants in the environments they inhabit using knowledge, complex thinking skills and ethical reasoning to guide those interactions. This motivation and even dedication to civic engagement should become a strong aspect of EfS. Whether education for sustainability uses wisdom as a model or schools educate for wisdom using sustainability as a context and conceive of sustainability as wisdom in action, educators can help their students to grow into citizens and professionals who will work toward sustainable development and actively engage in the many challenges that face humans on this planet.

References

Ardelt, M. (2004). Wisdom as expert knowledge system: A critical review of a contemporary operationalization of an ancient concept. *Human Development, 47*(5), 257–285.

Baltes, P. B. (1993). The aging mind: potential and limits, *Gerontologist*, *33*, 580–594.

Baltes, P. B., & Staudinger, U. M. (1990). The search for a psychology of wisdom. *Current Directions in Psychological Science, 2*, 75–80.

Bangen, K. J., Meeks, T. W., & Jeste, D. V. (2013). Defining and assessing wisdom: a review of the literature. *American journal of geriatric psychiatry, 21*(12), 1254–1266.

Bassett, C. (2006). Laughing at gilded butterflies: integrating wisdom, development, and learning. In C. Hoare (Ed.), *Oxford handbook of adult development and learning* (pp. 281–306). New York: Oxford University Press.

Bassett, C. (2015). Much madness is divinest sense: Wisdom and development. *Integral Review, 11*(2), 135–156.

Bassett, C. L. (2011). Understanding and teaching practical wisdom. *New Directions for Adult and Continuing Education, 2011*(131), 35–44.

Clayton, V. P., & Birren, J. E. (1980). The development of wisdom across the life span: A reexamination of an ancient topic. *Life-span development and behavior, 3*, 103–135.

Cortese, A. D. (2003). The critical role of higher education in creating a sustainable future. *Planning for Higher Education, 31*(3), 15–22.

Elkington, J. (1997). Cannibals with Forks: the Triple Bottom Line of 21st Century Business. *Capstone, 11*(12), 1–16.

Erikson, E. (1959). *Identity and the life cycle*. New York: International University Press.

Fien, J. (2004). Education for sustainability, In R. Gilbert (Ed.), *Studying society and environment: A guide for teachers*, Thomson, Victoria, pp. 184–200.

Gowdy, J. (2007). Avoiding self-organized extinction: Toward a co-evolutionary economics of sustainability. *The International Journal of Sustainable Development & World Ecology, 14*(1), 27–36.

Jackson, T. (2005). Live better by consuming less. *Journal of Industrial Ecology, 9*(1–2), 19–36.

Jackson, T. (2011). *Prosperity without growth: Economics for a finite planet*. Routledge.

Jones, P., Selby, D., & Sterling, S. R. (2010). More than the sum of their parts? Interdisciplinarity and sustainability. In P. Jones, D. Selby & S. R. Sterling (Eds.), *Sustainability education: Perspectives and practice across higher education* (pp. 17–38). London: Earthscan.

Kramer, D. A. (1990). Conceptualizing wisdom: The primacy of affect-cognition relationship. In R. J. Sternberg (Ed.), *Wisdom: Its nature, origins, and development* (pp. 279–313). Cambridge: Cambridge University Press.

Kramer, D.A. (2000). Wisdom as a classical source of human strength: Conceptualization and empirical inquiry. *Journal of Social and Clinical Psychology, 19*, 83–101.

Labouvie-Vief, G. (1990). Wisdom as integrated thought: Historical and developmental perspectives. In R. J. Sternberg (Ed.), *Wisdom: Its nature, origins, and development* (pp. 52–83). Cambridge, MA: Cambridge University Press.

Lander, L. A. (2009). Sustainability and the need for wisdom. *All about mentoring, 36*, 72–77.

Lander, L. A. (2015). Education for sustainability: Is thinking the key? *Sustainability: The Journal of Record, 8*(1), 27–31.

Lombardo, T. (2011). *Wisdom, consciousness, and the future*, Xlibris Corporation.

McMichael, A. J., Woodruff, R. E., & Hales, S. (2006). Climate change and human health: Present and future risks. *The Lancet, 367*(9513), 859–869.

Meacham, J. A. (1990). The loss of wisdom. In R. J. Sternberg (Ed.), *Wisdom: Its nature, origins, and development* (pp. 181–211). Cambridge: Cambridge University Press.

Moore, J. (2005). Seven recommendations for creating sustainability education at the university level: A guide for change agents. *International Journal of Sustainability in Higher Education, 6*(4), 326–339.

Newport, D., Chesnes, T., & Lindner, A. (2003). The "environmental sustainability" problem: Ensuring that sustainability stands on three legs. *International Journal of Sustainability in Higher Education, 4*(4), 357–363.

Orr, D. W. (2002). *The nature of design: Ecology, culture, and human intention*. New York: Oxford University Press.

Orwell, L., & Achenbaum, W. A. (1993). Gender and the development of wisdom. *Human Development, 36*(5), 274–296.

Rhodes, F. H. (2007). Sustainability: The ultimate liberal art. *Renewable Resources Journal, 25*(1), 6.

Shephard, K. (2008). Higher education for sustainability: Seeking affective learning outcomes. *International Journal of Sustainability in Higher Education, 9*(1), 87–98.

Sherwood, S. C., & Huber, M. (2010). An adaptability limit to climate change due to heat stress. *Proceedings of the National Academy of Sciences, 107*(21), 9552–9555.

Shephard, K. (2010). Higher education's role in 'education for sustainability'. *Australian Universities' Review, 50*, 13–13.

Sibbel, A. (2009). Pathways towards sustainability through higher education. *International Journal of Sustainability in Higher Education, 10*(1), 68–82.

Sinnott, J. D. (1998). *The development of logic in adulthood: Postformal thought and its applications*. New York: Plenum.

Slaper, T. F., & Hall, T. J. (2011). The triple bottom line: What it is and how does it work? *Indiana Business Review, 86*(1), 4–8.

Soini, K., & Birkeland, I. (2014). Exploring the scientific discourse on cultural sustainability. *Geoforum, 51*, 213–223.

Steinemann, A. (2003). Implementing sustainable development through problem-based learning: Pedagogy and practice. *Journal of Professional Issues in Engineering Education and Practice, 129*(4), 216–224.

Stephens, J. C., Hernandez, M. E., Román, M., Graham, A. C., & Scholz, R. W. (2008). Higher education as a change agent for sustainability in different cultures and contexts. *International Journal of Sustainability in Higher Education, 9*(3), 317–338.

Sterling, S. (2003). *Whole systems thinking as a basis for paradigm change in education: Explorations in the context of sustainability* (Doctoral dissertation, University of Bath).

Sterling, S. (2004). Higher education, sustainability, and the role of systemic learning. In *Higher education and the challenge of sustainability* (pp. 49–70). Netherlands: Springer.

Sternberg, R. J. (1998). A balance theory of wisdom. *Review of general psychology, 2*, 347–365.

Sternberg, R. J., Reznitskaya, A., & Jarvin, L. (2007). Teaching for wisdom: What matters is not just what students know, but how they use it. *The London Review of Education, 5*(2), 143–158.

Thomas, I. (2009). Critical thinking, transformative learning, sustainable education, and problem-based learning in universities. *Journal of Transformative Education, 7*(3), 245–264.

Trowbridge, R. H. (2007). Wisdom and lifelong learning in the twenty-first century. *London Review of Education, 5*(2), 159–172.

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2005). *Convention of the Protection and Promotion of the Diversity of Cultural Expressions, Paris, 20 October 2005*. Paris: UNESCO.

United Nations General Assembly. (1987). Report of the world commission on environment and development: Our common future, transmitted to the general assembly as an annex to document A/42/427—Development and International Co-operation: Environment, Retrieved on: 2009-06-15.

Wals, A. E. (Ed.). (2007). *Social learning towards a sustainable world: Principles, perspectives, and praxis*. Wageningen Academic Pub.

Warburton, K. (2003). Deep learning and education for sustainability. *International Journal of Sustainability in Higher Education, 4*(1), 44–56.

Yang, S. Y. (2001). Conceptions of wisdom among Taiwanese Chinese. *Journal of Cross-Cultural Psychology, 32*(6), 662–680.

Yang, S. Y. (2008). A process view of wisdom. *Journal of Adult Development, 15*(2), 62–75.

ecoGIS—A Solution for Interactive Facility Management to Support the European Eco-Management and Audit Scheme (EMAS)

Rainer Kettemann, Anete Fridrihsone and Volker Coors

Abstract

The University of Applied Sciences Stuttgart (HFT Stuttgart) is one of the first German universities to be a member of the International Sustainable Campus Network (ISCN). The university aspires to become a carbon—neutral campus, and is taking part in a number of initiatives and research activities to achieve that. One of the initiatives is the European Eco-Management and Audit Scheme (EMAS). The paper considers the development of a comprehensive tool, named ecoGIS, which aids EMAS processes and environmental facility management in general by allowing environmental data to be recorded and managed on interactive indoor maps, in a simple but reliable way. The ecoGIS toolset consists of a mobile app for data collection and web-services for 'on-the-fly' data analysis and reporting. The development enables all university members to participate in the EMAS process, as it is described in the paper. Special attention is paid to student inclusion in environmental management processes by crowdsourcing.

Keywords

Environmental facility management · Building management · EMAS · Indoor GIS · Indoor crowdsourcing

R. Kettemann · A. Fridrihsone (✉) · V. Coors
Hochschule Für Technik Stuttgart, Schellingstr. 24, 70174 Stuttgart, Germany
e-mail: anete.fridrihsone@hft-stuttgart.de

R. Kettemann
e-mail: rainer.kettemann@hft-stuttgart.de

V. Coors
e-mail: volker.coors@hft-stuttgart.de

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_4

1 Introduction

To make environmentally positive changes in buildings, accurate data is the key because the ecological footprint and the existing problems of a building are not obvious. While everybody can visually see a polluted river and run a few tests to find out water quality, it is quite different with buildings. According to UNEP (2009) "The building sector contributes up to 30 % of global annual greenhouse gas emissions and consumes up to 40 % of all energy". However, these high numbers seem to come as a big surprise to many people.

In public buildings such as university buildings, reducing the energy consumption is a challenge, not only from technical point of view. Such buildings are used not only by the owner, but mainly by the public, and in the case of universities, mostly students. Users are usually unaware of energy consumption; they do not directly benefit from energy savings. In order to raise awareness of these issues and motivate all stakeholders to change their behavior to reduce energy consumption and reduce greenhouse gas emissions, the HFT Stuttgart has started several initiatives. One of the first was to participate in the European Eco-Management and Audit Scheme (EMAS) in 2014, to establish sustainable corporate governance for the University. In addition, in 2015, a living lab for a climate-neutral city campus (EnSign) was initiated. To achieve this ambitious goal, the involvement of all relevant internal and numerous external actors is crucial. "*Furthermore it requires integrative and innovative packages of measures at different levels: an improvement in the urban context, the building substance and the plant engineering including the operating concept as well as the internal processes, the provision of renewable energy on campus, new financing models for energy renovation of public buildings, the development an appropriate mobility concept and an urban planning and infrastructure development strategy, but also significant behavioral adjustments of various user groups at the university*" (EnSign Project).

The first step in this direction is to raise awareness about the building energy consumption and environmental data. It is most convincing if it is based on real data of a building in question. Collecting and keeping track of this kind of data is a fundamental requirement of the EMAS process, and should also be visible to the public.

To the best of knowledge, in most of the EMAS applications, paper maps and digital charts and tables are used. On the paper maps a problem point would be marked and its data entered in some database. A problem point is a local area or equipment that is malfunctioning, for example, a leaking pipe, a broken window, a shutter, or a defective radiator. However, paper plans with problem point markings not only become obsolete very fast, but are also hard to communicate to all of the parties involved and to keep track of. Although there are tools that aid the problem of paper plans, there are no known tools that maintain the spatial quality when moving/transferring information into a digital environment. Some of the existing software, that has been reviewed, offers to store building blueprints and others graphics, but not in a spatially integrated way, which is a major drawback.

Environmental management is related to the facility management (FM) field, which increasingly adopts IT solutions. Bloodworth Rivers (2014) concluded "*Information, and building processes around this information, is critical to the wellness of any company. The utilization of the proper FM software, therefore, is essential for effectively managing facilities*". Computer-Aided Facility Management (CAFM), which is facility management support and operations handled with the help of information technologies, largely focuses on information about the facilities. Two most common features in CAFM are interactive databases and interactive graphics. "*One of the primary reasons behind the adoption of IT based facility management solutions is the requirement for optimal utilization of resources and organizational assets. An organization can significantly reduce the operational costs if it utilizes its resources and assets optimally*" was researched by Marketsandmarkets (2015). A significant part of utilizing facility resources and assets optimally is awareness of existing issues and their impact.

However, a combination of CAFM and Geographic Information Systems (GIS), which would provide the spatial component, is a largely unexplored territory, due to the following reasons:

- Buildings are 3D objects with overlaying floors,
- Indoor maps are not common in GIS,
- Navigation through several overlaying maps is usually time-consuming.

The ideal, desired high-end solution is an interactive building problem point management tool with spatial components, a possibility to actively interact and query records and with an automatic issue placement option by using Indoor Positioning Systems and automatic floor detection. It should allow all stakeholders to easily report any environmentally relevant observation with minimal effort and also enable tracking of the reported issues by both, the stakeholder who can see what has happened to the reported issue, as well as the environment manager who can check if the situation improves over time.

2 Requirements

The solution named ecoGIS was planned as an easy to use crowd sourcing system with specialized analysis and administration functionality. Therefore it has to serve the following three requirements, which are different from available standard facility management solutions:

- Integration of interactive maps,
- A wide range of involved participants with different roles,
- Large comprehensiveness in functions.

The utilization of GIS tools can fulfill all of the needs. By giving environmental facility problems locations and standardized descriptions, they can effortlessly be overviewed and analyzed in a standardized manner. Interactive maps with geocoded features allow reporting problems at and with their locations, as well as visualizing the present and historic situation. The maps are suitable for grasping the big-picture and easily pin-pointing problematic areas. Maps make the data and the work with data more visual and more interesting, which is especially important when adding crowdsourcing to a solution. GIS tools are fully designed to deliver spatial and static analysis of data.

Overall ecoGIS has to deliver data collection, data tracking, analysis, and reporting and management tools. It involves many participants with different roles. To cover all functionalities and cater to all involved participants, ecoGIS must be realized as a unified system with strictly divided modules for each purpose. Participants who will focus on data collection should not be confused with analysis tools and participants, who are focused on analysis, will be offered to use these functionalities with ease. Each user must find ecoGIS easily available and usable; knowledge, location and time should not be limiting anybody from using it. The tool must be able to be used virtually anywhere at any time. That means: no work stations, no installed software, no special hardware, no training sessions.

Crowdsourcing will be used to collect data. Piffer et al. (2015) propose a crowd sourcing approach to map indoor environments based on OpenStreetMap. OpenStreetMap is "*an openly licensed map of the world being created by volunteers using local knowledge*" (OSM 2016). In some ways ecoGIS will benefit from such initiatives as a map of the building interior will act as spatial reference system in ecoGIS. If students can be motivated to participate, the ecoGIS data base will be filled with a lot of data in essentially real time. The crowdsourcing approach will also promote an individual's responsibility in sustainability issues, making people more aware and responsible. Due to deployment of crowdsourcing, ecoGIS must be designed in a way that ensures trust in collected data and reduces possible human errors. In addition, the data collection process must be designed seamless and rather interesting to allure and indulge the crowd.

Responders must be equipped with tools to always assess all data and to get messages if important new data is added. While responders deal with it in the field, managers need tools that deliver transparency and an overview of the situation and actions taken. Because data reaches full value when it is analyzed, managers need convenient analysis tools. GIS analysis tools are generally not user-friendly to non-GIS specialists. Therefore ecoGIS must avert that by replacing each chain of analysis functions into one button readily available.

3 Actors

The ecoGIS solution is planned to impact almost all university members. However, each user group will have a different role to play and will need different functions for it. Also data access privileges will be different. Users of ecoGIS can be divided

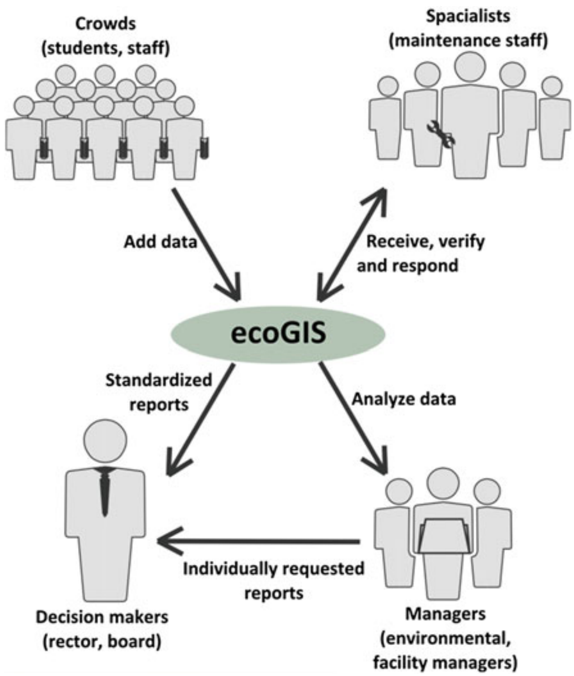


Fig. 1 The ecoGIS main actors and data paths

into four groups related to their role at the university. The four groups and data paths are shown in Fig. 1.

3.1 Actors and Their Roles

Decision makers from university's head, like the rector, need information that is ready to be consumed for decision making. They need a good overview of the big-picture, which can be grasped easily. Therefore standardized, topic specific reports and maps will be delivered by ecoGIS. Strategic decisions can be then embedded in real, quantifiable, and visualized data.

Managers like campus' environmental managers and facility managers need analysis tools to overview the situation and work progress, to establish focus areas, and to decide where to apply corrections. For commissioned tasks they need work chain transparency. Data visualization and report generating functionalities are required for this role to allow managers to report to higher level decision makers or others.

Specialists like maintenance staff need more localized information which allows them to respond to reported problems. Specialists need to validate new data and issue work orders to tackle problems. They need a clear overview of their own work in their area of responsibility regarding to the collected data.

Crowd is all university members—mostly students, but also specialists, managers and regular staff members. They all should have access to data collection functionality. The crowd's main function is to report problem data points. However, to keep them engaged there has to be two-way information exchange giving response about the impact.

Each group of actors should have the ecoGIS tailored to its needs and have access to different functions. Core data will be available to all, but some actors will see more detailed information.

In addition to described actors, ecoGIS system will need an administrator for two purposes:

- Monitor and maintain the entire system,
- Perform special analysis that occasionally might be available, but is not essential.

4 User Interfaces

The solution must be easily accessible by all involved actors with regards to their role, therefore, it will be linked to a data cloud and different services will be used—a mobile app for lower level functions like data collection and field-responses and web-services for higher level functions, especially for analysis, reporting, and problem responses.

4.1 Mobile App

Problem points regard different aspects of sustainability, like energy, water, safety, emissions and others. The problem point data collection will be handled with a mobile app. All data will be added by dropping problem points on interactive indoor maps where they will show up in different symbols to immediately indicate problems' aspects as shown in Fig. 2. To fill in the problem-point information a user will be taken through semi-automatically filled, proofed fields. Data fields representing spatial information will be filled automatically by taking values from underlying maps, like room number, which contains floor and building information. Users manually only have to fill other fields, however, to reduce human error, most of data fields will be pre-populated with auto-complete pick-lists, linked property fields, data type validators and default auto-fills that are based on statistically most common values. Essentially users will have to select only problem's aspect without assistance. In addition to written data users will also be able to attach one or multiple pictures of the problem.

For example, by choosing the aspect "energy" for a new problem point, offered fields will provide pick-lists that are only relevant to energy, and if the statistically most common problem description is "defected bulbs", it will already be chosen in

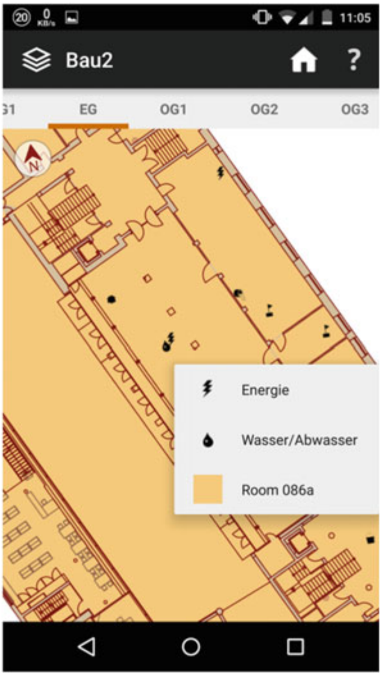


Fig. 2 Screenshot of the ecoGIS prototype app which shows problem points on an interactive indoor map

a pick-list, but available to change. All users should feel guided through the data collection process by hand.

Adding a problem point will need user's awareness of the location; in which building, and on which floor? GNSS based positioning which is a standard in mobile devices can't be used in buildings. Indoor Positioning Systems (IPS) are the current technologies to deliver such service, but they are time-consuming to implement and costly as described by Farid et al. (2013).

Easier to realize is semi-automatic floor detection by using relative air pressure being temporarily adjusted to a building and knowing the height of floors. The barometer sensors in mobile devices have become a standard, which allows adding automatic floor detection to the ecoGIS app. However, due to limitations imposed by building inner air conditioning systems, different sensor sensitivity and need for regular calibration, as researched by Muralidharan et al. (2014), automatic floor detection must be made easily switched on/off.

Taking the mentioned obstacles into account, an easy to use manual selection process for background floor maps is currently the best solution which can be updated later by automated processes.

Since the ecoGIS app will mostly be used by crowd, data trustworthiness and security is becoming an important issue. To ensure data source validity and avoid fake reports, only universities members will be accepted. Therefore app's users will be linked to university's inner member system. All university's members—students, academic force, administration and other staff—have an account and email. So actor roles can be automatically assigned when users connect to the universities network, as ecoGIS is a part of new university standard. That ensures that all ecoGIS users will be uniquely and easily identifiable, without a need for an extra user data base. It also means nobody needs to go through an additional sign up process.

Besides collecting, the mobile app will offer tracking and responding functionalities, which mostly will be useful in field. Members with specialist role will benefit from such functionality. They need two pieces of information first and mostly—what is the severity of a reported problem, and where it is located. The location part is handled by reporting all problems on a digital map. The severity is handled by automatic filtering. As soon as new problem point is collected, it goes through filtering. For example, if water leak or broken window is reported, a specialist receives an automatic prompt warning on his phone. If a problem point is marked with high priority, specialists get a warning that invites him to inspect a problem soon. Specialists also get messages about other additions to be informed, but since they pass the filter as lower level severity, immediate attention is not necessary.

These warnings and messages will be delivered to both, the phone app and web-services, however, when specialists will head to a location to inspect/fix the issue, they will need to make changes to this problem point and add a work order. Problem's validation is necessary to make sure all are accounted for. Changes in problem point data fields means that specialists have re-evaluated original reporting. Adding a work order on a problem point means that specialists have evaluated the problem and can start a fixing process. It will also be possible to order other specialists attention to specific problem points or to warn managers.

By using a mobile app for these actions, specialists at the same time plan their work, inform others involved, avoid paper slips with lost information, save time by location aware field visits, as well as save money by readily responding to most severe problems.

For bigger campuses, specialists can be working in zones and based on location. A certain specialist will only receive prompt information regarding his work zone.

Specialists will use ecoGIS as their work tool, the crowd is voluntarily participating. To ensure ecoGIS app doesn't become wearisome, two-way information must be channeled. For example, a user could get an automatic message "Thanks, your reported problem point has been fixed". In future, when rich statistics will be collected users could get messages with information about how much CO_2 was prevented from entering atmosphere or similar environmentally driven messages.

4.2 Web-Services

While the mobile ecoGIS app is designed to fit field environment, ecoGIS web-service is designed to grant actors more functionalities, easier overview and proper working environment. The crowd will be provided with public overview maps and general information on improvements to further engage them to be active. The main purpose of the available content for crowd is to emphasize the importance of their participation.

Specialists and managers will be the most active web-service users. Services will be available through a website where the interface and functions will be customized for each actor based on credentials coming from the logging in process.

Specialists, who used the app in field to add information, can overview work orders at a work station, utilize included planning tools and guidelines to tackle problems fast and efficiently. Managers will have access to analytics and reporting tools. They easily can generate summaries, run filters, and produce statistics and visual charts. The ecoGIS web-service will provide a direct reporting mechanism by emailing the information to decision makers or specialists. They might request a special, individually created report. So managers are getting enabled to give well-grounded directives.

All closed work orders and fixed problem points will be saved in the data base with a time stamp. As time goes by and information starts to accumulate, time series will become available. With time series functionality animations showing the changes over time within a defined timeframe can be presented to users.

The overall goal is to create a user friendly system and to avoid functions that might need GIS-focused knowledge. Therefore the most common analyses will be made available by clicking only one button. However, a need for customized tools and analyses might arise. That is when managers connect system administration to request custom analysis.

5 The Data Model

For a successful implementation the underlying data model is essential. It has to consider the requirements mentioned before and it has to support all actors' needs. Therefore the following questions have to be taken into account:

1. What processes will be aided by the collection of data? (EMAS audits, faster maintenance response)?
2. How problems (point features) will interact with underlying maps?
3. What is the minimum amount of data fields that bring the maximum amount of information?
4. How to deliver maximal reliability and error-proofness?
5. What future enhancements can be anticipated?

Data fields will be designed to fully support information collection for EMAS audits. Other widely used environmental standards, like ISO14001 and ISO50001, also will be looked at to derive important data fields. Besides data fields that regard environmental state, fields regarding the maintenance state are necessary, for

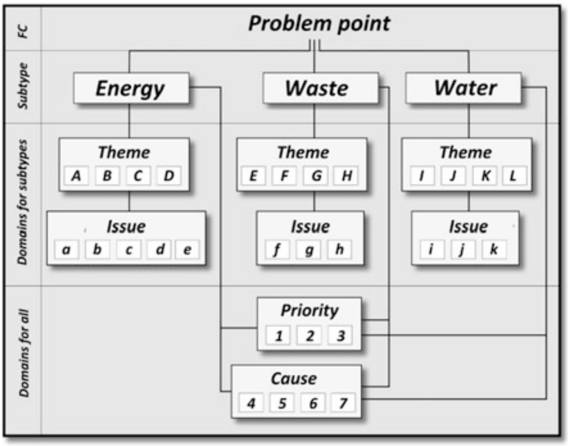


Fig. 3 An illustration how standalone and linked pick-lists work. A user starts his choice at the top

example, a time stamp of when problem was entered, who is in charge of fixing it, and so on. The crowd will only be allowed to see and work with environmental state data fields.

Underlying maps have to be interactive and carry information about each building, floor and room. Problem points placed on such maps and the maps themselves can be spatially analyzed together. If location attributes are filled in automatically from the underlying map, problem points can be also retrieved from the database without spatial functionality.

Due to crowdsourcing and a wide range of involved participants, the data collection process must be fast and simple. The sheer count of data fields that must be manually filled have to be kept to minimum. When designing data fields, each of them must be weighted according to its importance. The philosophy is as follows—better have hundred recordings with five data fields, than five recordings with hundred data fields.

People will be easier to engage if the data filling process is simple and streamlined. Therefore decision points must be kept to a minimum. The easiness of data filling is tightly correlated with the quality of the data model. Standalone and linked pick-lists (see Fig. 3) have to be designed where it is possible. In some occasions a re-writeable pick-list will be the best choice—it relieves users' decision point and simultaneously provides plausible information. By integrating these principles, gainers will not only be crowd members, but also specialists and managers who will receive data with low human error possibility.

As previously mentioned not all technologies are at the stage to usefully implement them. However, the data model must predict what properties might be necessary in future. For example, maps should be geographically referenced and oriented correctly, as well as have floor height information.

6 Beneficiaries

Firstly, ecoGIS will improve environmental performance of campus buildings. By deploying ecoGIS each building on campus will become as an alive organism that is aided before it even gets ill. The environmental problem points will become readily reported and averted. The critical building areas soon after will become obvious and long term remediation measures can be planned.

Quantifiable statistics will be available years after ecoGIS is implemented, but it is expected to see a decrease in energy consumption, a decrease in money resources spent on environmental and facility management, and an increase of work productivity in involved positions. Boosted organizational morals due to ecoGIS delivered transparency are also expected to appear.

The direct beneficiaries will be universities' employees whose work will become easier. Specialists will know where exactly their attention is needed and will have tools that benefit their workflow. Managers will gain oversight as well as trustable analysis based on real data. Decision makers will be able to base their decisions on data that is not subjectively interpretable. Overall, ecoGIS will improve work quality for all.

The indirect benefit will be a change of mindset. Involving students and others in crowdsourcing will make them more aware of their environment and, most importantly, their responsibility and role in it. Some of the problem points are a result of human behavior. When the crowd becomes engaged, there might be a shift in how occurring issues will be looked at—from a bystander point of view to a participant point of view. They will become more environmentally friendly. It is hoped that an engaged crowd will carry this sense of responsibility beyond campus and into daily life, starting a multiplying effect.

7 Implementation

A prototype version of ecoGIS has already seen the light of day. It was developed as master's thesis by Fridrihsone (2015) and later on improved as part of the EnSign research project carried out by HFT Stuttgart. It essentially serves as a simplified, ready-to-use prototype.

The first step in prototype creation was to design a data model and choose appropriate services and tools. The data model was designed with great regard to EMAS processes and by keeping in mind future enhancements like automatic floor detection. The data model included field definitions, field property definitions and means of data communications (e.g. problem point ↔ floor location). By adding more data fields that mostly regard specialists' maintenance needs, the existing data model can be used as a base for future enhancements.

To create the prototype, commercial services and tools, namely Esri's ArcGIS, were used for technical development, because it allows a streamlined processing in all parts (desktop tools, web-services, mobile app). Various data formats can be

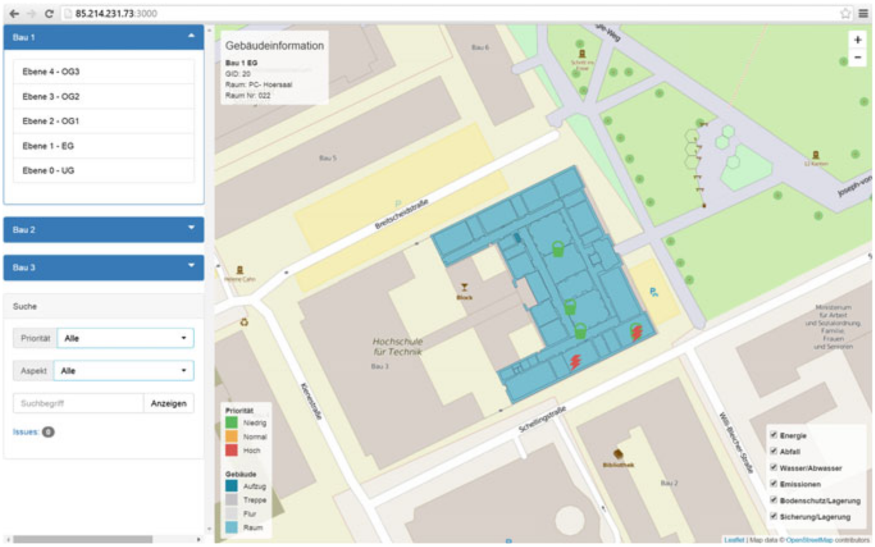


Fig. 4 Web based interface to view problem points and their priority (low—*green*, medium—*orange*, high—*red*). On the *left side*, users can select the building and floor of interest, and an aspect (energy, waste, water, emissions, soil, or safety). Base Map (c) OpenStreetMap Contributors

connected. The prototype focuses on data collection—the mobile part of ecoGIS. Therefore, a native app was developed by using ArcGIS Runtime SDK for Android as a mobile component and ArcGIS Online was used as web-service and data repository.

The prototype gained sympathies from HFT Stuttgart's environmental managers and allowed to refine the ecoGIS requirements and focus areas. The app was given to selected students for field tests. More ideas of what should be implemented and how to make it easier to use emerged. User feedback was collected and taken into account. The result was not only sufficient to use it in real-world tests and gain valuable insights, but it also highlighted why the final solution must be independent from third party services—to fully control the features, functions and interface of the web-service by the ecoGIS administrators.

A prototype for such an independent web-service was created based on a PostGIS database and the open-source runtime environment Node.js for developing server-side web applications. This web-based visualization (Fig. 4) shows all reported problem points per building and floor. It also includes search functions. The aspects are visualized using different symbols, where the color indicates the priority of an issue.

To shape the attitudes of crowd members more students can already be engaged in semi-volunteer data collection processes. This will help to create an ecoGIS implementation plan regarding crowd participation and getting essential feedback.

8 Summary and Outlook

Prototype solutions based on the described design are already developed and in use by students for data collection and additional developments. Based on ecoGIS, an evaluation of the impact of this citizen science concept for monitoring the environment will be investigated in future. Besides the “citizen as a sensor” concept for data collection, the impact of data analysis and visualization of the “environment-friendly” behavior of citizens and students will be analyzed.

With the fast developing technologies all around, ecoGIS enhancements like IPS and automatic floor detection should be adopted when the time is ripe. With those enhancements users will instantly see their location on a map when they launch the app. Problem points can then be posted with just a few clicks. Specialists can navigate to problem points by using an indoor navigation system if they are not familiar with the buildings. Other user friendly enhancements, like addition of voice memos might be considered.

The focus of ecoGIS is environmental management and sustainability, but the current design allows adjusting the same principles and technology to virtually any process that has spatial indoor quality. By creating new data models for other topics, e.g. custodial points instead of problem points, the system can be extended into other areas. Similarly, by adjusting some of the functions, like specialist response function; the system can be adapted to operate as a static spatial data repository, for example, for all university’s computers. In that case, IT administrators would have an overview of all computers and their location. They could be remotely called to fix issues and they can keep track of this equipment easily. The application possibilities are vast.

In more distant future ‘Internet of Things’ could be implemented. Automatic and remote sensor control would allow immense energy savings. The ecoGIS solution is at the beginning of its journey. It doesn’t have to be finished to start bringing positive changes; it will remain for some time a work in progress. But even at the early stages the outlook is promising to achieve a more environmentally sustainable campus with more responsible members.

Acknowledgments The authors would like to thank Daniel Worm for valuable input on the EMAS process, Roland Hahn for his initiative and support, Marc Philipp Jensen, Lukas Komarek, and Benjamin Lebherz for implementing the web service prototype, and the Ministry of Science, Research and the Arts Baden-Württemberg for funding the EnSign project.

WISSENSCHAFT FÜR NACHHALTIGKEIT

Baden-Württemberg
MINISTERIUM FÜR WISSENSCHAFT, FORSCHUNG UND KUNST

References

Bloodworth Rivers, T. (2014). *How facility managers solve big challenges through FM software*, 2.4.2014. http://www.iofficecorp.com/blog/how-facility-managers-solve-big-challenges-through-fm-software. Last access January 29, 2016.

EnSign. (2015). http://www.hft-stuttgart.de/Forschung/Projekte/Projekt131.html/en?set_language=en&cl=en. Last access January 28, 2016.

Farid, Z., Nordin, R., & Ismail, M. (2013). Recent advances in wireless indoor localization techniques and system. *Journal of Computer Networks and Communications, 2013*.

Fridrihsone, A. (2015). *Building management with ArcGIS* (Unpublished master's thesis). University of Applied Sciences Stuttgart.

Marketsandmarkets. (2015). *Facility management market by solution (asset management, space and move management, EMS, maintenance management, project management, real estate portfolio management), by Service, by Org Size, by Verticals, by Regions*—Global Forecast to 2020. http://www.marketsandmarkets.com/Market-Reports/facilities-management-market-1030.html. Last access January 29, 2016.

Muralidharan, K., Khan, A. J., Misra, A., Balan, R. K., & Agarwal, S. (2014). Barometric phone sensors—More hype than hope! In *ACM HotMobile'14*, February 26–27, 2014, Santa Barbara, CA, USA. doi:10.1145/2565585.2565596

OSM. (2016). OpenStreetMap. http://www.openstreetmap.org/. Last access January 28, 2016.

Piffer, S., Dorigatti, N., & Conti, G. (2015). i-locate—Indoor/outdoor LOCation and Asset management Through open gEodata. In *Geomatics Workbooks n° 12—FOSS4G Europe Como 2015*. http://geomatica.como.polimi.it/workbooks/n12/FOSS4G-eu15_submission_183.pdf

UNEP. (2009). *Buildings and climate change—summary for decision-makers*. United Nations Environment Programme on Sustainable Buildings & Climate Initiative. http://www.unep.org/sbci/pdfs/SBCI-BCCSummary.pdf. Last access January 29, 2016.

Author Biographies

Rainer Kettemann has been head of the GIS laboratory at HFT Stuttgart (University of Applied Sciences Stuttgart) since 1995. He became a Professor at HFT Stuttgart in 1990. His main areas of work are GIS applications, data interoperability and GNSS. In 2002 he became the Study Dean for the German course Vermessung und Geoinformatik.

Anete Fridrihsone received her Master degree in Photogrammetry and Geoinformatics from HFT Stuttgart in 2015 and Bachelor degree in Transportation Engineering from Riga Technical University in 2013. Since 2015 she has been working at HFT Stuttgart to design and develop ecoGIS prototype app and she also has worked in research with focus area on 3D building models in conjunction with energy.

Volker Coors (*1968) is Professor in Geoinformatics and Computer Science at HFT. His research is focused on 3D Geographic Information Systems and Information Logistics, in particular data management and visualisation of large 3D urban models. He holds a Diploma degree with honours in Computer Sciences and a doctoral degree in Computer Graphics from Technical University of Darmstadt. He is chairing the 3D Portrayal Service Standard Working Group of the OpenGeoSpatial Consortium (OGC) and represents the OGC in the Web3D consortium.

A Real-World Lab Approach to the Carbon Neutral Campus Transition: A Case Study

Lisa Botero, Michael Bossert, Ursula Eicker, Jan Cremers, Nansi Palla and Christiane Schoch

Abstract

Universities, with their complex systems, influence on local economies and socio-cultural place-making, serve as a framework for the sustainable development (SD) transformation within communities. In support of Germany's Energy Transition and the goal of climate neutral state governance by 2040, the state of Baden-Württemberg selected seven universities to create real-world lab projects addressing various sustainability-related themes. This paper presents a case study of the University of Applied Sciences (HFT) Stuttgart's EnSign real-world lab, which employs transdisciplinary research methods to find transferable solutions for the transition to a climate neutral inner-city campus. EnSign's approach includes the development of an iterative, optimization-based, knowledge capture process that is inclusive of both external and internal stakeholders. Goals are to catalyze the campus transition, adjust user behavior, and increase energy efficiency by developing new building operating concepts, public building renovation financing models, stakeholder integration methods, and institutional management structures. A brief review of the supporting policy framework, theoretical foundations, and topical areas of implementation are presented. Initial findings are described with regard to communication strategies, civil society integration, and institutional preparedness for the transition. Conclusions reflect on the relevance for real-world lab experiments.

Keywords

Transdisciplinary research · Carbon neutral campus · Energy efficiency · Real-world lab

L. Botero (✉) · M. Bossert · U. Eicker · J. Cremers · N. Palla · C. Schoch
Institute of Applied Research, University of Applied Sciences Stuttgart,
Schellingstr. 24, 70174 Stuttgart, Germany
e-mail: lisa.botero@hft-stuttgart.de

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_5

1 Background

Due to their roles in research and public service and as educators of future leaders, decision-makers and citizens, higher education institutions (HEI) are understood to play a critical role in understanding and promoting sustainable development (SD) (Disterheft et al. 2013). Leal Filho (2011) holds that despite the numerous guiding frameworks and the international agreements or declarations several hundred universities have signed committing to SD, many have not succeeded in implementing the principles of SD due to misconceptions or lack of resources, comprehension, appreciation, or interest. The German state of Baden-Württemberg, which has a goal of climate neutral administration by 2040, seeks to address these challenges by providing resources to its universities for sustainability transitions (Baden-Württemberg 2012). This policy supports the broader German Energiewende, the national transition to a renewable energy-based, efficient and sustainable energy system (BMU 2012).

Multiple ministries support this policy, including the Ministerium für Wissenschaft, Forschung und Kunst (MWK), akin to a ministry for science, research and the arts, which views the state as having both the responsibility and opportunity to implement SD principles (MWK 2012). In 2013, the MWK minister specifically cited the use of real-world laboratories as the research concept most suited to this task because they bring stakeholders from universities, politics, administration and civil society together from the research start, allowing for solutions to be applied to real societal problems (MWK 2013a).

The publication “Wissenschaft für Nachhaltigkeit” (science for sustainability) report (MWK 2013b) recommended that the state catalyze multiple initiatives to increase overall capacity for SD in society, including the establishment of real-world labs, extension of teaching and study in SD, and the use of universities of applied science as integrated research and learning centers for SD (ibid). The report also recommended that five climate neutral universities be established to serve as models by 2018, funded by the Innovation and Quality Fund (IQF). The IQF aims to strengthen the quality and performance of universities by promoting SD integration in teaching, knowledge transfer, and research (MWK 2012). Supported by IQF, HFT Stuttgart’s Centre for Sustainable Development (ZNE) was established in 2013 as the university department responsible for campus sustainability.

2 HFT Stuttgart and EnSign

Universities of applied sciences, especially those focused on design, planning and building, are particularly qualified to lead sustainable development at HEIs, given their traditional ties to industry, research on the latest sustainability innovations, and years of tradition in inter- and transdisciplinary education. In 2015, the MWK awarded funding to seven real-world laboratories, including experiments with sustainable mobility, urban development, national park management, the textile industry, space-sharing, and the transition to a climate neutral campus, the latter of which is called the EnSign Reallabor at University of Applied Sciences (HFT) Stuttgart (MWK 2014). EnSign is coordinated by the HFT Stuttgart's Center for Sustainable Energy Technology (zafh.net), one of six research centers within its Institute for Applied Research that investigates sustainable economics and management, integral architecture, and sustainable development, among other topics (HFT 2016).

The platform "Hochschulen für Nachhaltige Entwicklung" or HNE (Universities of Applied Sciences for Sustainable Development) was established in 2005 and includes the 21 universities of applied sciences in Baden-Württemberg. The HNE network aims to establish education for sustainable development (ESD) and is recognized as an official project of the UNESCO "Decade of Education for Sustainable Development" 2005–2014. ESD focuses on acquisition of knowledge, skills, and values necessary to improve the quality of life of learners, including raising public awareness about SD and training faculty and staff to integrate SD in curricula (Disterheft et al. 2013). Five recommended SD design fields for universities of applied sciences were defined (i.e. teaching, research, operations, transfer and governance), which were adopted by the ZNE as focal areas (RTWE 2012).

A review of the project area, transformation process, transdisciplinary research, and real-world lab approach are presented as context for the development of EnSign. Descriptions of the research focal areas are then presented, followed by initial findings observed during the first project year.

3 Project Area

The Stuttgart metropolitan area, with a population of about 2.7 million, is the capital city of the state of Baden-Württemberg, Germany, which is rated the number one in the EU-wide innovation comparison, leading in high-tech industries, manufacturing, and research (BW Statistisches Landesamt 2014). The state-owned university buildings serving about 4000 students were founded in 1873 and today are located in a dense urban context (Fig. 1).

4 Methods

4.1 Transformation

The nature of the sustainability problems is a wicked one, whereby classical methods of observation and modeling are insufficient and new approaches are needed to deal with confounding system connections, complexity, and ambiguity around the problem definition and potential solutions (Lotz-Sisitka et al. 2015). It is

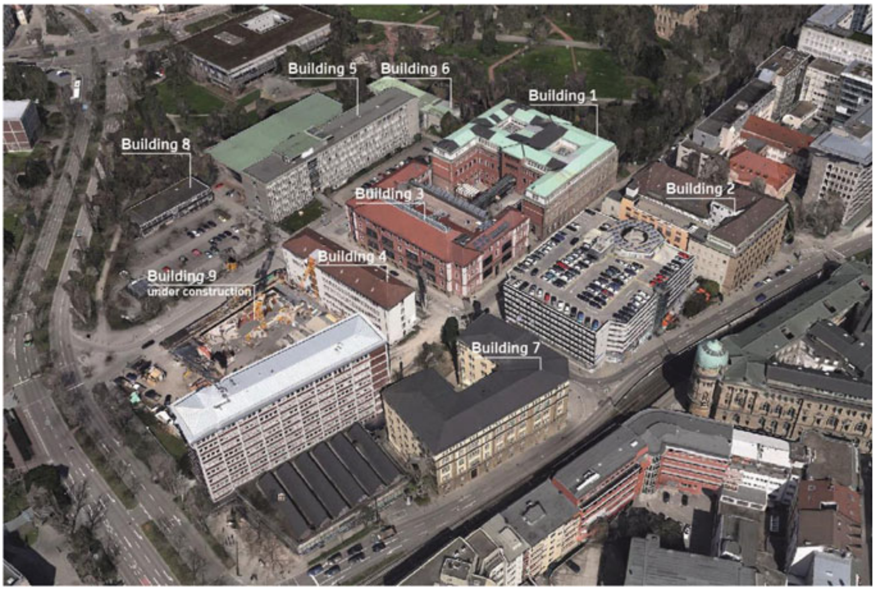


Fig. 1 Aerial image of HFT Stuttgart inner-city campus in 2015 (website https://www.google.de/maps)

understood that this complexity requires new societal paradigms, which in turn require new ways of producing knowledge and making decisions, moving toward system transformation not only optimization (ibid). EnSign deals with the transformation to a climate neutral campus and the transdisciplinary approach provides guidance on to achieve this shift.

Viewed as a means of sustainability learning, transdisciplinary research (TR) is characterized by the contribution of civil society, in contrast to interdisciplinary research (Scholz and Steiner 2015a). TR requires scientific and societal views be considered and links between abstract and case-specific knowledge be forged to facilitate problem-solving for the common good (Pohl and Hirsch Hadorn 2008). Lang et al. (2012) defined transdisciplinarity, adapted from Matthias Bergmann's presentation at the International Network for Interdisciplinarity and Transdisciplinarity, as "a reflexive, integrative, method-driven scientific principle aiming at the solution or transition of societal problems and concurrently of related scientific problems by differentiating and integrating knowledge from various scientific and societal bodies." Inferred from these definitions, TR focuses on societally relevant (real) problems, shared learning from within and outside of academia, and transferable solutions. TR methods have informed the EnSign approach and motto "HFT as a neighbor in the region", referring to its integration of external participants into the research (HFT 2015).

The ideal typical conceptual model of transdisciplinary research involves three phases (not necessarily in this order): (i) "problem identification," co-definition of an identified problem; (ii) "problem analysis," co-creation of solution-oriented, transferable knowledge; (iii) "(re-)integration and application" of co-created knowledge. The knowledge produced through TR can be categorized as systems knowledge (observation of existing system), target knowledge (desired target state), and transformation knowledge (needed to achieve transformation) (Pohl and Hirsch Hadorn 2008). These concepts are used in this paper, however, the challenges surrounding creating a common understanding them for all EnSign participants are discussed in the Initial Findings.

EnSign adopts a TR approach in addressing the super-ordinate real problems of climate change, Germany's Energy Transition and the state's climate neutral administration policy, manifested as the climate neutral campus goal and engages in problem co-definition, co-creation and eventually, integration of solutions into its own system and transfer of know/how to relevant neighbors.

4.2 Real-World Labs

Several science-society research arrangements have been developed in light of the expansion of TR and the need to conduct experiments in real-world settings to test solutions to sustainability problems (Trencher et al. 2014). Schäpke et al. (2015) have documented new experimental settings for research in and with society including: real-world type laboratories (Wagner and Grunwald 2015), living laboratories (Voytenko et al. 2015), and urban transition labs (Loorbach and Rotmans 2010; Wiek and Kay 2015). The German term "Reallabor" does not yet have a shared understanding in the German-speaking discourse on sustainability research, a number of partially overlapping definitions have been offered (MWK 2013a, b, the German Advisory Council on Global Change WBGU 2014, Schneidewind 2014; Wagner and Grunwald 2015; Schäpke et al. 2015). The common concept of all real-world labs is to combine the strength of experimental laboratory environments with the real-world context, the reconciliation of methods, terminologies and concepts (ibid). EnSign employs a real-world lab approach by developing and testing energy efficiency technologies, urban development plans, financial schemes, and behavioral incentives supporting SD on its own buildings and users.

4.3 Iterative Approach

EnSign employs an iterative process (Fig. 2) involving the refinement of the research question via biannual co-production workshop series where objectives laid out in the project application are crafted into specific tasks, which are then transferred as tasks to the researchers and acted upon to produce target, system and transferable knowledge in collaboration with external partners. The results are then presented for further refinement or even the creation of subsequent questions, with a return to co-definition or in the future, re-integration into actual societal or scientific practice. The MWK commissioned an accompanying research consortium

Fig. 2 Iterative process of EnSign TR approach

composed of the Institute for Socio-Ecological Research and universities with expertise in implementing real-world labs to support and guide the Reallabor projects (ISOE 2016). This group meeting biannually to analyze, assess, and discuss the progress and challenges.

It is understood that incorporating non-academic stakeholders in this process may increase legitimacy, ownership and accountability for both problems and the potential solutions (Scholz and Steiner 2015b). Relevant social actors with practical knowledge who co-define research questions can be authorities on the obstacles for implementation and serve as pioneers for transformation knowledge. EnSign incorporates external stakeholders selected in part on their interest in contributing to climate neutral development in urban districts, their potential influence on implementation obstacles, and ability to transfer developed solutions into practice. External partners include:

- *practice partners* to address the structural, technical, historical preservation, financial and communication aspects (e.g. chambers of trade/craftsman (HWK), the Association of German Architects (BDA), financial experts, citizens' associations, energy consultants, engineers, state and local authorities); and
- *transfer partners* to ensure concrete multiplication factors (e.g. German Sustainable Building Council (DGNB), Federal Chamber of German Architects (BAK), national organizations of energy consultants, energy cooperatives and federal ministries).

5 EnSign Real-World Lab Focal Areas

5.1 Project Management

Project Management (PM) includes the communication, participation, education and transfer activities to support the TR concept. PM also drives the iterative approach through coordination of: biweekly project team (staff) meetings to discuss new results, resolve problems, coordinate workshops, and debate ideas to facilitate the exchange between work packages and researchers; faculty and staff meetings every six weeks to define work package details; and monthly PM team and the project director meetings with the chancellor to review progress. Biannual meetings are organized for all stakeholders to discuss progress, research questions, and co-production goals.

5.2 Urban Planning

When addressing the development of a climate-neutral campus in the inner-city neighborhood, a study of the urban context is useful. The status of urban development and energy consumption of the campus buildings (Zone 1) the surrounding buildings of the city quarter (Zone 2), as well as the inner city zone (Zone 3) will be analyzed (Fig. 3). Based on stakeholder analysis results, scenarios for mobility, energy concepts, and environmental and landscape planning will be developed. Suggested energy-based urban quarter development will be further refined within community workshops to gather system and target knowledge and visualized via a 3D data model to communicate energy performance.

5.3 Energy Management and User Behavior

Energy management is approached through the gathering of operational data on the main energy flows. Software will be designed for the inclusion of both the BMS-based and mobile-captured data, which will form the basis for the data

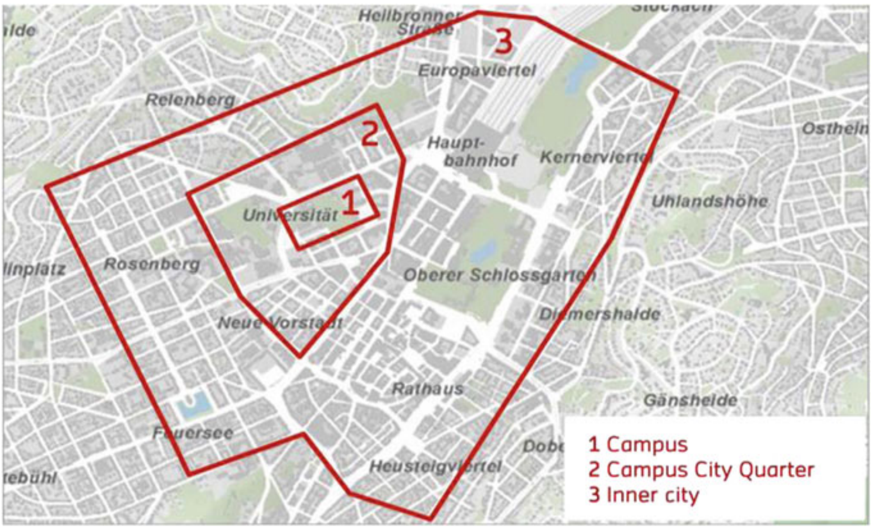


Fig. 3 The three zones of the urban context study (Map based on: http://www.stuttgart.de/geoportal)

importation into the 3D campus model and further into the Virtual Living Lab platform (VLLP). VLLP users will also be able to populate the platform and communicate with university operations directly about wastes, suggestions, criticism, and shortcomings. Qualitative-quantitative surveys will be used to understand typical behavior and elaborate on motives. Monitoring will detect potential areas for user behavior improvement, which will contribute to transferable incentive concepts. App users become active in energy management and system knowledge production.

5.4 Architecture and Refurbishment

Refurbishment strategies for energy-efficient architecture and usage-based analysis of the university buildings will be developed, including building renovation roadmaps. The level of 'carbon neutrality' attainable will be determined using life cycle assessment (LCA) methodologies of the DGNB (German Sustainable Building Council) green building criteria. An investigation of local urban design codes in so far as they allow for the integration of renewable energy technologies into facades or building envelopes is also included, especially in the historic preservation context. A catalog for sustainable refurbishment options and prioritization of transferable measures will be also developed to support implementation.

5.5 Integration of Renewable Energies

The energy demand of university buildings can be effectively reduced through the refurbishment and optimization of energy supply technology. Locally available renewable energy sources (as close as possible to 100 %) will mainly be considered; for example, solar is one of the most promising energy sources in terms of building integration, especially when electricity and/or heating are needed. However, given the concrete building stock of the HFT, energy for cooling is also needed. Through long-wave radiative emissions from roof areas to the night sky, cooling power can be generated. Renewable energy integration requires highly unified solutions with optimal adjustment of production and consumption in the urban context. Coordination with neighborhood actors is an opportunity to incorporate systems and target knowledge into the design of a collective urban district concept, supported by the TR approach.

5.6 Indicators of Sustainability

Indicators will be developed to provide an assessment of progress toward the target of carbon neutrality. Key performance indicators from various areas must be brought together (e.g. economic, environment, society, governance, architectural and urban indicators) to reliably assess the complex transition. Analysis should simplify the decision-making process for energy efficiency investment via easy to follow sustainability criteria, supporting transferability of solutions.

5.7 Sustainable Finance

Measures for climate protection often call for high volume investment into energy efficiency measures, which lead to an equally high financing needs. The extent to which sustainable finance instruments (e.g. grants, loans, energy cooperatives, cash flow-based finance instruments, crowd funding) can contribute to the energy transition and climate protection goals of a university will be investigated. Goals are to gain as many potential investors as possible (e.g. university staff, students' parents, citizens etc.) in order to accumulate the highest possible investment on citizen capital. Knowledge of how energy savings returns (e.g. income from feed-in tariffs) could provide financing to the university will also be sought.

5.8 Engagement

HFT Stuttgart's newly established participation in the International Sustainable Campus Network (ISCN) and in the Inter-University Sustainable Development Research Program (IUSDRP) are meant to increase and broaden SD engagement. Participation bolsters legitimacy and relevance of the university's sustainability goals and link local actions to global initiatives in research and teaching at HEIs. The analysis effort required for dissemination via these channels, which itself mirrors the transdisciplinary process, provides an opportunity to harmonize internal TR literacy.

The establishment and definition of a Green Office to engage the campus community in SD is also foreseen. Student change agents will raise awareness about SD on campus, propose new research questions, and inform university administration about perceived problems and desired changes. In turn, the university will relay messages about its SD strategy and support a critical engagement and transfer by social engagement events that meaningful learning opportunities. System, target, and transformation knowledge will be produced and exchanged between the administration, staff and student groups.

6 Initial Findings

The EnSign real-world lab method is understood as a living process rooted in the aforementioned theoretical frameworks, but not yet fully defined. Thus far, the iterative co-definition of research topics has yielded alterations in the emphasis or re-prioritization and new questions have been added (e.g. implementation of a local energy supply grid). The co-production of research with a team over 30 researchers has begun at the university, engaging various stakeholders, including students, employees, public agencies, associations and private companies. Initial urban, energy, economic and stakeholder analysis have been completed and the installation of energy monitoring technology has begun. The app gathering energy inefficiency information is in the initial testing phase for accuracy and effectiveness.

An intense learning process via critical institutional self-reflection on the temporal, practical, integrative aspects is underway. The methodological approach was found to depend strongly on the driving force behind the project development, research in this case. Thus, the design reflects the research competences and existing networks of the university and the advanced technological know-how needed to aid implementation is largely available. However, one of main challenges of SD in HEIs is implementing comprehensive education for the whole university (Leal Filho 2015). To that end, other critical aspects are less well developed at the moment, but are necessary to overcome several micro-level transfer problems observed thus far and as described by Disterheft et al. (2013), including strong disciplinary models and misconceptions of SD. Thus, improving ESD integration in teaching, engagement of civil society stakeholders, TR literacy and capacity building, forging appropriate management structures and defining indicators and assessment methods are areas of concerted effort.

6.1 Teaching

Sterling (2004) argues that sustainability education requires a transformative approach in which the learner is immersed in this system complexity and ESD should not be simply tacked onto existing curricula and structures. New learning opportunities are being developed in tandem with EnSign to address this challenge such as real-world lab-based bachelor and master theses and programs such as "Studium Integrale", launched by the ZNE and didactic center. The voluntary program addresses the integration of SD across three curriculum areas: key qualifications (e.g. methods, social skills); general education (e.g. ethics, sustainable development, interdisciplinary work, philosophy of science); and special electives (e.g. political education, service learning, foreign languages, intercultural competence). Obtaining feedback on the effectiveness and contribution of such initiatives toward a wider SD literacy has proved difficult and assessment methods are now under design.

6.2 External Stakeholder Integration

Brandt et al. (2013) also identified practitioner engagement and generating impact as potential problem areas of TR. The three kinds of actors (scientific community, legitimized decision-makers such as representatives from public institutions, and public at large) distinguished by Scholz and Steiner (2015a) have been integrated within EnSign. However, who else might be included as civil society has proven more difficult to define. While citizen-led crowd-funding of public institution sustainability transition would bring ordinary citizens into the fold, the extent to which students might “count” through their participation in voluntary initiatives, is undefined. Also, the extent to which the time investments of society at large can or should be compensated financially is not yet understood. Contributions and workshops attendance by society at large are currently acts of volunteerism based on interest and availability, thus the equity of the joint learning process has been called into question, as not all demographics of external actors are equally represented. The changing science-society relationship in the German science system described by Schneidewind and Augenstein (2012) reviews the relationships among German states, public universities, non-university research institutes, and free ecological institutes. As next a step, the influence of these structures on the development of sustainability science will be analyzed to inform more diverse engagement and empowerment possibilities for civil society.

6.3 TR Literacy

The development of a transformative literacy whereby civil society, political and economic actors are empowered to make and promote sustainability-oriented changes is still the initial stages (Schneidewind 2013). TR poses an institutional challenge to the established research system, requiring new methods, suitable training of scientists and other aspects of system capacity building (Schneidewind and Augenstein 2012). Divergent values, perspectives, interpretations of TR, types of knowledge and integration methods have been observed to undermine method integration and subsequent management of diverse datasets and standards adoption. The establishment of a common language has proven to be a prerequisite to productive collaboration and tailored communication strategies for external and internal team members are needed. The iterative method of continuous modifications of operations and research questions have been shown to require a flexibility dependent on strong interdisciplinary relationships, which in turn require trust and time to build legitimacy. It has been determined that internal training for research team members should be developed to build capacity for shared aims and basic literacy of TR and even SD concepts as applied to HEI.

6.4 Management Structures

Institutional self-reflection brought about by EnSign has shown the need for the restructuring or integrating the sustainability design areas of the ZNE. While the ZNE focal areas of teaching, research, operations, transfer and governance recommended by the HNE echo Cortese’s (2003) university system dimensions (e.g. education, research, university operations and external community), a high level of internal or external community integration has not yet been realized. The need for the development of a Campus Engagement Campaign was determined and launched by Greening HFT, the student-led sustainable campus initiative, at the Global Climate University Forum held at the United Nations Framework Convention on Climate Change Conference of Parties (COP21). Greening HFT grown in membership and presence due to engagement by the EnSign team, integrating ESD into everyday campus life. As a result, an internal analysis is underway examining how the sum of parallel movements in teaching, governance, and research could be coordinated into a Green Office.

6.5 Assessment

Assessment in the form of proof or targeted communication of the added value from TR could also help to motivate a wider variety of stakeholders to participate (Scholz and Steiner 2015b). The need for a more robust assessment and reporting dimension, as suggested by Lozano (2006), has been determined, beginning with the definition of climate neutrality itself. While the common goal of climate neutrality has been established, a shared understanding of the concept was determined necessary to streamline data management, define project boundaries and reconcile methodologies, but existing standards are insufficient. For example, German standards (EnEV and DIN 18,599) include calculation forms for net final and primary energy demand, heating, cooling, hot water, ventilation, lighting, and auxiliary space; however, common area electricity and outdoor space are not included. These factors are currently being discussed with specialist external partners, as they form part of a holistic campus carbon footprint calculation. Indeed, no standard sustainability criteria for the university campus profile have been identified, however, the DGNB is leading the development of this topic as external partners. Defining sustainability indicators as a combination of criteria from DGNB and the existing Eco-Management and Audit Scheme (EMAS) has been determined as fundamental requirements for a climate adaption strategy. If/how EMAS can be enhanced to integrate sustainability/corporate responsibility is now under evaluation in attempt to better address the problem complexity.

7 Conclusions

The EnSign real-world lab has been designed within the pioneering policy framework of the German Energy Transition and the MWK climate neutral governance goals, resulting in an institutionalization of real-world laboratories. Real institutional changes are occurring, as evidenced by new administrative units, strengthening of new student SD-oriented groups, and new integrative educational programs. Challenges include defining carbon neutrality and assessment criteria, integrating methods, communicating, capacity building, and engaging civil society. Critical self-reflection to reconcile teaching and governance structures with SD goals is required, as is a minimum TR literacy, to effect systemic SD integration.

More robust assessment criteria must be included in research design, especially for meaningful contribution of external stakeholders. The real-world lab approach is malleable and responsive to change from within the institution, but having a common goal such as carbon neutrality, however defined, keeps project management, methods, and assessment aligned with the TR process.

Dealing with the wicked problem of SD and the subsequent re-design of tomorrow's campuses and curricula to provide solutions, requires new values, ways of conducting research, and relationships between academia and civil society actors. While the technical project results will be of transferable to other public buildings, the study of the transformation process catalyzed by EnSign, including the definition of development scenarios, methods, indicators, and assessment protocols, is perhaps of greater value to the societal SD transition than singular energy efficiency achievements.

Acknowledgments The EnSign Reallabor Project is funded by the Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg, Wissenschaft für Nachhaltigkeit.

Baden-Württemberg
MINISTERIUM FÜR WISSENSCHAFT, FORSCHUNG UND KUNST

WISSENSCHAFT FÜR NACHHALTIGKEIT

References

Baden-Württemberg. (2012). Last Accessed March, 2016.https://www.baden-wuerttemberg.de/de/service/media/mid/weg-zurklimaneutralen-landesverwaltung/

BMU. (2012). Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global. *Federal Ministry for the Environment (BMU)*. Last Accessed March 28, 2016 http://www.dlr.de/tt/Portaldata/41/Resources/dokumente/institut/system/publications/leitstudie2011_bf.pdf

BW Statistische Landesamt. (2014). *Innovationsindex 2014: Baden-Württemberg im europäischen Vergleich*. Last Accessed March 25, 2016. https://www.statistik-bw.de/Service/Veroeff/Monatshefte/20150104.mha

Brandt, P., Ernst, A., Gralla, F., Luederitz, C., Lang, D., Newig, J., et al. (2013). A review of transdisciplinary research in sustainability science. *Ecological Economics, 92*, 1–15.

Cortes, A. (2003). *The Critical Role of Higher Education in Creating a Sustainable Future*. Planning for Higher Education, March-May.

Disterheft, A., Caeiro, S., Miranda Azeiteiro, U., Filho, L. (2013). Sustainability science and education for sustainable development in universities: A way for transition. In S. Caeiro et al. (Eds.), *Sustainability Assessment Tools in Higher Education Institutions* (pp. 3–27). Berlin: Springer.

HFT Stuttgart. (2015). Kick-off Veranstaltung am 12. Juni EnSign Reallabor Klimaneutraler Innenstadtcmapus. Last Accessed March 29, 2016 https://www.hft-stuttgart.de/Aktuell/Presse-Marketing/Pressemitteilungen/2015/Ensign_Reallabor.pdf/de

HFT Stuttgart. (2016). *HFT Stuttgart zafh.net: Research Center for Sustainable Energy Technologies*. LastAccessed March 25, 2016 https://www.hft-stuttgart.de/Forschung/Kompetenzen/zafh/KB_zafh.net/Bro_zafhnet_en.pdf/en/download

ISOE. (2016). Accompanying research for 'real-world laboratories' in baden-württemberg. *Institute for Social-ecological Research (ISOE)*. Last Accessed March 25, 2016 http://www.isoe.de/en/projects/current-projects/transdisciplinary-methods-and-concepts/accompanying-research-for-real-world-laboratories-in-baden-wuerttemberg/

Lang, D., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., et al. (2012). Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustainability Science, 7*(1), 25–43.

Leal Filho, W. (2011). About the role of universities and their contribution to sustainable development. *Higher Education Policy, 24*, 427–438.

Leal Filho, W. (ed.) (2015). Education for sustainable development in higher education: reviewing needs. In *Transformative Approaches to Sustainable Development at Universities: Working Across Disciplines*. *World Sustainability Series* (pp. 3–23). Berlin: Springer.

Loorbach, D., & Rotmans, J. (2010). The practice of transition management: Examples and lessons from four distinct cases. *Futures, 42*, 237–246.

Lotz-Sisitka, H., Wals, A., Kronlid, D., & McGarry, D. (2015). Transformative, transgressive social learning: Rethinking higher education pedagogy in times of system global dysfunction. *Current Opinion in Environmental Sustainability, 16*, 73–80.

Lozano, R. (2006). A tool for a graphical assessment of sustainability in universities. *Journal of Cleaner Production, 14*, 963–972.

MWK. (2012). *Minister Funds Sustainable Science*. Last accessed March 25, 2016 http://mwk.badenwuerttemberg.de/de/service/presse/pressemitteilung/pid/wissenschaftsministerium-foerdert-nachhaltige-wissenschaft-1/

MWK. (2013a). *5 Millionen Euro für die Einrichtung von Reallaboren*. Last accessed March 25, 2016 http://mwk.badenwuerttemberg.de/de/service/presse/pressemitteilung/pid/5-millionen-euro-fuer-die-einrichtungvon-reallaboren-1/

MWK. (2013b). *Wissenschaft für Nachhaltigkeit: Herausforderung und Chance für das baden württembergische Wissenschaftssystem*. Last Accessed March 25, 2016 https://mwk.badenwuerttemberg.de/fileadmin/redaktion/mmwk/intern/dateien/pdf/Wissenschaft_f%C3%BCr_Nachhaltigkeit/Expertenbericht_RZ_MWKBroschuere_Nachhaltigkeit_Web.pdf

MWK. (2014). *Geförderte Reallabore der Hochschulen in Baden-Württemberg*. Last accessed March 25, 2016 https://mwk.badenwuerttemberg.de/fileadmin/redaktion/mmwk/intern/dateien/Anlagen_PM/2014/084_PM_Anlage_Gefoerderte_Reallabore.pdf

Pohl, C., & Hirsch Hadorn, G. (2008). *Core Terms in Transdisciplinary Research in Handbook of Trandisciplinarity*. Berlin: Springer, pp. 427–432.

Schäpke, N., Singer, Browdowski M., Stelzer, F., Bergmann, M., & Lang, D. (2015). Creating space for change: Real-world laboratories for sustainable transformations: The case of Baden-Württemberg. *GAIA, 24*(4), 281–283.

RTWE. (2012). *Empfehlungen für nachhaltigkeitsspezifische Gestaltungsfelder an Hochschulen*. Last accessed March 25, 2016 http://www.rtwe.de/index.php?eID=tx_nawsecuredl&u=0&file=fileadmin/doc/06-HNE/hne-7-gf.pdf&t=1458993744&hash=f55a59986903dbbcc0215174246d7891b37520a3

Schneidewind, U. (2013). Transformative literacy. Gesellschaftliche Veränderungsprozesse verstehen und gestalten. *GAIA, 22*(2), 82–86.

Schneidewind, U. (2014). *Urbane Reallabore—ein Blick in die aktuelle Forschungswerkstatt*. pnd online, 3, 1–7. Last accessed March 25, 2016 http://www.planung-neu-denken.de/images/stories/pnd/dokumente/3_2014/schneidewind.pdf

Schneidewind, U., & Augenstein, K. (2012). Analyzing a transition to a sustainability-oriented science system in Germany. *Environmental Innovation and Societal Transitions, 3*, 16–28.

Scholz, R., & Steiner, G. (2015a). The real type and ideal type of transdisciplinary process: part I-theoretical foundations. *Sustainability Science*, *10*, 527–244.

Scholz, R., & Steiner, G. (2015b). The real type and ideal type of transdisciplinary process: Part II-theoretical foundations. *Sustainability Science, 10*, 653–671.

Sterling, S. (2004). Higher education, sustainability, and the role of systemic learning. In P. B. Corcoran, & A. Wals (Eds.), *Higher Education and the Challenge of Sustainability, Problematics, Promise and Practice.* Dordrecht: Kluwer Academic Press.

Trencher, G., Bai, X., Evans, J., McCormick, K., & Yarime, M. (2014). University partnerships for co designing and co-producing urban sustainability. *Global Environmental Change, 28*, 153–165.

Voytenko, Y., McCormick, K., Evans, J., & Schliwa, G. (2015). Urban living labs for sustainability and low carbon cities in Europe: Toward a research agenda. *Journal of Cleaner Production*, 1–10.

Wagner, F., & Grunwald, A. (2015). Reallabor als Forschungs-und Transformationsinstrument. Die Quadratur des hermeneutischen Zirkels. *GAIA, 24*(1), 26–31.

Wiek, A., & Kay, B. (2015). Learning while transforming: Solution-oriented learning for urban sustainability in Phoenix, Arizona. *Current Opinion in Environmental Sustainability, 16*, 29–36.

Authors Biography

Lisa Botero is a researcher at HFT Stuttgart's Centre for Sustainable Energy Technology (zafh.net) where she manages a Marie Skłodowska-Curie Action doctoral program on urban energy and works for the creation of a Green Office as part of the EnSign real-world lab. She holds a Master of Environmental Management from the Yale School of Forestry & Environmental Studies, with a focus on sustainable cities and urban ecology applications for environmental protection, conservation and restoration. As Environmental Manager for the City of Miami Beach, she designed climate adaptation and resource management projects, creating the city's first Sustainability Plan. She also holds a Master of Public Administration, with a focus on sustainability policy-making in local government.

Michael Bossert is managing director of HFT Stuttgart's Centre for Sustainable Energy Technology (zafh.net) and is responsible for the project management of the EnSign RealLabor. He holds a Dipl.-Ing. (FH) in architecture with the focus on sustainable buildings and HVAC technology from the HFT Stuttgart. He holds a Master of Interior Architecture and Design (IMIAD) from HFT Stuttgart and Lahti University of Applied Sciences with a focus on furniture and product design. After graduation, he worked in engineering, architecture and design offices in Finland and Germany. Since 2008, he works as a researcher and project manager in zafh.net and the Centre for Integral Architecture at the HFT Stuttgart.

Prof. Dr. habil Ursula Eicker is a physicist, professor and research director at the HFT Stuttgart. She obtained her PhD in amorphous silicon thin-film solar cells from Heriot-Watt University in Edinburgh and then worked on the process development of large-scale amorphous silicon modules in France. Since 2002, she has been the scientific director of the research center on sustainable energy technologies (zafh.net) and the Institute of Applied Research of HFT Stuttgart. Her current research emphasis is on the development and implementation of active solar thermal cooling technologies, low-energy buildings, control strategies and simulation technology, heat transfer in facades, etc. and the role of these technologies in sustainable urban development.

Prof. Dr. Ing. Jan Cremers is an architect, professor and director the Integral Architecture research center at the HFT Stuttgart. He obtained his PhD at the Technical University Munich and has been a professor of at the HFT Stuttgart architecture department since 2008 in the area of building technology. He is also head of HFT's climate engineering program. His current research topics range from building level to materials and components including energy plus design, integration of renewable energies, active solar technologies with a special focus on interdisciplinarity. In 2011, he was awarded an innovative university teaching fellowship by the 'Stifterverband für die Deutsche Wissenschaft' and is a frequent lecturer at various German universities and abroad in Austria, Poland, the U.S. and Japan.

Nansi Palla is a research assistant at HFT Stuttgart's Center for Integral Architecture. She received her bachelor of arts and master's degree in architecture from the HFT Stuttgart while participating in the Solar Decathlon Europe of 2010. Her current research focuses on PVT (renewable energy), EnSign real-world lab, and Soft (Building Membrane Development Project) and she also works for project acquisition. She also has professional experience working as an architect in the private sector.

Christiane Schoch is a research assistant at HFT Stuttgart's Center for Integral Architecture where she works with the EnSign Project and project acquisition. She holds a Dipl.-Ing in architecture from the University of Stuttgart. She spent five years researching energy efficiency of urban quarters at the Technical University of Darmstadt and has experience in private architecture firms and as an independent energy consultant. She is a member of the German Sustainable Building Council working groups for industrial and urban districts and her current research focus is on climate neutral urban quarters.

Sustainable Academic Libraries: A Campus Partnership at Michigan State University

Eric D. Tans

Abstract

Through the sharing and reuse of materials, libraries have an inherent sustainability as institutions that reduce the environmental impact associated with producing informational resources. Libraries must, however, take additional steps in order to be truly sustainable. This paper describes the Michigan State University Libraries' history of sustainable development, both independently and in collaboration with the MSU Sustainability Office. The MSU Libraries has been a pioneer in sustainable development on campus, creating a Library Environmental Committee to organize educational programming and encourage sustainable practices within the library long before other campus units. The Environmental Committee, MSU Sustainability, and other operational departments on campus have collaborated on educational and programmatic projects, resulting in increased recycling rates in the library, decreased energy use, a 100 % landfill diversion rate for materials deaccessioned from the library collection, and a pilot program collecting compost from both public areas and office spaces. This paper will be useful for anyone interested in sustainability in academic libraries or sustainability based collaborations between campus units.

Keywords

Academic libraries · Sustainability · Collaboration · Campus operations

E.D. Tans (✉)
Michigan State University Library, 366 W. Circle Drive, W441 (13),
East Lansing, MI 48824, USA
e-mail: tans@msu.edu

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_6

1 Introduction

Michigan State University (MSU) is a large research institution founded in 1855 and located in East Lansing, Michigan, USA. MSU provides services to not only the student population of 39,143 undergraduate and 11,400 graduate students (Michigan State University 2015c), but also, as a land-grant university, MSU provides services to the entire population of the state of Michigan. MSU features a 5200 acre campus with 538 buildings, including residence halls, administrative offices, and 95 academic buildings (Michigan State University 2015c). University campuses typically require a significant amount of energy (Ohashi and Shimoda 2014) and MSU is no exception. Although the total CO_2 emissions have declined every year since 2010, the main campus still produced 477,089 million metric tons of CO_2 in 2014 (Michigan State University 2015b). In light of this large footprint, MSU is moving to develop sustainable operations on campus. Overseeing these operations is MSU Sustainability, a department of the Infrastructure Planning and Facilities (IPF) unit.

The ideas of sustainability and sustainable development have become so commonly used in the realms of business, politics, academics, and even popular culture that determining a single definition poses a challenge (Bookhart 2012). Many works discussing sustainability opt for describing it as an intersection between the disparate studies of economics, the environment, and social issues (Barlett and Chase 2004) or put another way: ecology, economy, and equity (Henk 2014). Pushing beyond this description, sustainability is also defined as a process in which the temporal present is transformed into a future that lasts for generations (Barlett and Chase 2004; Bookhart 2012). This chapter offers a reflection of sustainability through the changes to the ongoing processes within the MSU Library in collaboration with MSU Sustainability and other IPF units.

The library serves the information needs of MSU as well as community patrons throughout Michigan. The collection contains over 7.5 million unique volumes, many of which are housed in print in the Main Library (MSU Library 2015a). The Main Library is housed in a midcentury building divided between separate wings and totaling 458,913 square feet. Construction on the west wing completed in 1955 and the east wing in 1967 (MSU Library 2015b). The library's staff is comprised of 82 librarians, 123 support staff, and approximately 240 student employees and is a hub of activity on campus. The Main Library is open for use 24 h a day and gate count statistics show an average of 4580 people entering the Main Library over the course of a day. The MSU Library also features two branch libraries, but for the purposes of this chapter any discussion of the library will refer only to the Main Library building.

Libraries are frequently involved in promoting sustainable practices (Rowley 2006; Alpi 2000; Le Ber and Gregory 2004) and the MSU Library is no exception. The Library Environmental Committee (LEC) is one of the pioneering sustainability committees at MSU and has shared in collaborations with MSU Sustainability and several other closely related IPF departments. The shared history and collaborative efforts of these closely aligned organizations has been instrumental in making the library a more sustainable and resilient.

2 Methods

The purpose of this chapter is to present a case study outlining both the historical development and current practice of sustainability at the MSU library. The methods used for data collection included field visits, virtual correspondence and in person discussions with stakeholders, and analysis of internal documents and current practice. These data combine to produce a picture of the partnerships driving sustainable development within the library. The expected outcome of this assessment is to provide a template for other library institutions to adapt for use towards sustainable development.

3 History of Sustainability at MSU

The MSU Library's history of green activity precedes the formal founding of LEC. As early as 1982, a group of library staff volunteers began recycling library subscribed newspapers, using personal vehicles to deliver the papers to an off-campus a recycling drop-off center. In 1988, the library installed recycling bins for newspapers, office paper, colored paper, and cardstock. The library also successfully lobbied the MSU University Stores to provide post-consumer recycled paper for use in on campus computer labs and photocopy machines. The high volume of printing and copying done within the library was instrumental in allowing the provision of recycled paper to be cost effective for the University Stores.

The earliest formal iteration of LEC received approval in 1990, creating the Recyclers of MSU Libraries committee. The committee's official charge was to educate library staff and to encourage recycling in the library. As recycling paper became more prevalent across the MSU campus, the committee broadened its focus to include conserving natural resources and eliminating waste related to paper and printing, electricity and energy use, heating and cooling, cleaning and office supplies, and transportation. The committee's charge also expanded to include a role advising library administration on environmental issues, educating staff, maintenance of reference materials related to the environment, and to liaise with other university units, such as the MSU Surplus Store and Recycling Center. These changes came into effect in 1998, along with a name change to Library Environmental Committee.

Since its inception, LEC has developed an active presence within the library. It employs a three pronged approach to engaging with staff, focusing on communication, education, and outreach. LEC regularly communicates with library staff through a monthly environmental email called the *Ecogram.* The *Ecogram* topics vary, but they typically focus on practical ways to be environmentally friendly either at home or in the office.

LEC's educational activities consist of providing training for all new library employees. An environmental orientation provided by a LEC member is an official part of the new employee orientation protocol. New employees are briefed on recycling practices, energy conservation at the office, and other conservation and environmental issues. The goal is to remove potential roadblocks to conservation and recycling by providing new employees with an understanding of local practices. By minimizing confusion about green practices early on, new employees are more likely to participate in library conservation efforts (Kelly et al. 2006). The LEC member providing the orientation is available to answer any questions and new employees are encouraged to contact a LEC member with any concerns after the orientation.

LEC also organizes outreach activities both in and outside of the library. Each semester LEC arranges for speakers to participate in the Library Environmental Series. These speaking events are usually informational in nature and provide staff and students with an opportunity to learn about environmental matters both on campus and in the greater community. In addition to the Library Environmental Series, LEC has an ongoing relationship with the assistant curator of the Beal Botanical Garden (located directly west of the Main Library) to conduct educational tours of the garden. Library Environmental Series events and the Beal tours are scheduled at midday to allow staff to attend during the lunch hour.

In many respects, LEC was the pioneering environmental organization on campus that paved the way for other groups. The precursor to MSU Sustainability was the University Committee for a Sustainable Campus, which was approved by the academic governance committee in 1998 (DeLind and Link 2004). One of several key players in the formation of the University Committee for a Sustainable Campus, Terry Link, was longtime MSU librarian and also a founding member of LEC. Shortly after the formation of the University Committee for a Sustainable Campus, Mr. Link and other committee members successfully applied for a U.S. Environmental Protection Agency Sustainable Development Challenge Grant of nearly $250,000 USD to form an Office of Campus Sustainability (OCS) and hire a program director to run the office (T. Link, personal communication, 11/25/2015). The OCS was formed in 2000, with Mr. Link named as the program director. Mr. Link instilled in the OCS similar principles as LEC and led the office for eight years. In 2014 the office changed its name to MSU Sustainability.

Other IPF departments related to sustainability, including the MSU Surplus Store and Recycling Center and MSU Bikes, all of which were formerly organized under MSU Sustainability, continue to work closely in tandem with the library on sustainable development projects. MSU Recycling manages the waste and recycling from every building on campus and also maintains a publicly accessible recycling drop off site. Recyclables are sorted in the materials recovery facility and baled for shipping to materials vendors. The recycling center handles cardboard, newspaper and office paper, glass, plastics, and most relevant to the library, books and journals deaccessioned from the collection. MSU adheres to the philosophy of highest and best use, meaning they favor reuse and reduction over recycling with landfilling as a last resort (Michigan State University 2015a).

Also aligned to the highest and best use philosophy, the MSU Surplus Store accepts unwanted and used office supplies, electronics, computers, and furniture for refurbishing and reuse (Michigan State University 2015d). These items, together with recycling and composting, divert a significant portion of waste away from the landfill. MSU's current diversion rate of 57 % shows progress towards achieving the goal to divert 70 % of all waste on campus away from the landfill by 2017 (Michigan State University 2014). The MSU Surplus Store and Recycling Center share a joint facility in a Leadership in Energy and Environmental Design (LEED) Gold certified building on campus that features solar panels and water remediation among other green building features.

MSU Bikes operates a fully functional bicycle store on campus, providing new and used bicycles and accessories for sale, bicycle rentals, and repair and maintenance services to members of the MSU community. In addition to the store, MSU Bikes also advocates for bicycling as a means of transportation on campus and offers free classes on bicycle safety and bicycle commuting. Bicycle transportation on campus not only reduces greenhouse gases associated with travel, but also helps to mitigate the limited parking space available on campus (Toor and Havlick 2004). According to data from MSU Bikes, the total number of bicycles registered on MSU's campus has increased steadily from 4844 in 2006 to 8629 in 2013. Bicycles make commuting across MSU's large campus faster and more convenient for students, staff, and faculty alike and provides significant greenhouse gas savings over equivalent trips via automobile (Lindsay et al. 2011).

MSU Sustainability works to engage students, faculty, and staff on issues of sustainability. Students are encouraged to apply for research funding through the Be Spartan Green Student Project Fund. This fund gives MSU students an opportunity to plan and carryout sustainability related research projects up to $5000 USD. The students are then able to utilize the campus as a laboratory in order to investigate practical means for advancing sustainable practices on campus. Outreach to faculty and staff takes place primarily through the EcoReps program. The EcoReps are a loose network of university staff and faculty members that model and encourage sustainable practices and serve as sustainability ambassadors for their units on campus (MSU Sustainability 2015). EcoReps serve a similar role as LEC within their units, and several LEC members also participate in the EcoReps program.

4 Collaborations

The shared history of LEC, MSU Sustainability, MSU Surplus Store and Recycling, and MSU Bikes has resulted in a number of collaborations between the groups. These collaborations include both daily operations and special projects. Daily operations include managing waste and recycling at the library and handling items removed from the library collection. The groups' collaboration on special projects include a campus compost pilot program, the library staff bicycle, assistance with Earth Day outreach, and analysis of the library building's energy usage via a process known as building commissioning. Library operations and projects will be described in further detail in the subsequent sections with an emphasis on how they influence the library's sustainable processes.

5 Recycling and Waste Management

As a large institution in the middle of an active campus, the library generates a significant amount of both waste and recyclable or reusable materials. MSU Recycling supplies bins for recycling, the landfill, and most recently, for composting organic waste. MSU Recycling does not collect single stream recycling, and provides separate bins for recycling office paper (a higher quality paper that can be recycled into a larger number of new products), a lower quality mixed paper/paperboard, and combined plastics and metal. These bins, along with bins for landfill bound waste, are readily available in both staff offices and public areas and are collected by custodial staff and shipped for processing or sorting at the material recovery facility.

According to MSU Recycling data, during the 2015 calendar year the library generated a total of 131,892 lbs. of landfill versus 292,199 lbs. of materials diverted either through recycling or reuse programs. That results in a waste diversion rate of nearly 69 %, on track to matching the campus wide goal of 70 % by 2017.

While the library's diversion rate is progressing towards MSU's overall goal, there are still areas for improvement. A waste sort conducted in conjunction with MSU Recycling in December 2013 examined landfill waste taken from the Main Library. MSU Recycling set aside material collected from the library and 5 library staff members sorted the contents into two categories: recyclable and non-recyclable materials.

The total amount of material handled in the waste sort was 649 lbs. Of that total, 92 lbs. of materials were sorted into the recyclable category, revealing that slightly over 14 % of the material being sent to the landfill could potentially be recycled instead. Extrapolating that percentage to the entire body of landfill waste from 2015, as much as 18,696 lbs. of potentially recyclable materials could have been sent to the landfill from the library that year.

Additionally, landfill waste collected from office and staff areas had very little recyclable material contamination. The majority of recyclables found in landfill containers came from public areas with high student traffic, including the library café. This is consistent with the results of other studies that have found many undergraduate students lack clear understanding of the benefits of participating in sustainable activities (Kaplowitz et al. 2009) and remain unmotivated to make lifestyle changes (Eagle et al. 2015). Student engagement to encourage correctly sorting recyclables into the appropriate container is an area for improvement. The successful sorting from staff areas, however, indicates that LEC's efforts to educate staff about sustainability and local recycling practice has successfully encouraged recycling and sorting waste, which is consistent with findings from Kelly et al. and Kaplowitz et al. (2006, 2009).

6 Composting Pilot

MSU has identified composting organic waste as the next step towards achieving the 70 % waste diversion goal (Michigan State University 2014). Composting not only reduces waste generation, but it also limits CO_2 emissions (Kranert et al. 2010). LEC and MSU Recycling have partnered on implementing a pilot program to collect compostable organic waste within the library. MSU Recycling representatives and LEC members collaborated to determine the optimal collection locations for bins and a satisfactory schedule for pickup. At the end of 2015, the library had 13 organic waste bins; 10 spread throughout various communal office spaces in the building and 3 dedicated to the library café, primarily to collect coffee grounds and food waste.

The library composting pilot launched in March of 2014 and has removed over 6444 lbs. of organic waste from the library's waste stream as of the end of 2015. The library was one of the first major buildings on campus to collect compost and has produced nearly half of the total compost collected across all participating buildings. The composting program is now successfully implemented in 18 academic buildings on the MSU campus and has collected a total of 13,801 lbs. of compostable material. MSU Recycling is able to further minimize the environmental impact of the composting program by conducting all of their pickups using a bicycle and trailer rather than a box truck. MSU Recycling began measuring the total distance traveled hauling compostable material by bicycle in September, 2015. Between September and December of 2015, hauling this material has resulted in traveling 235 miles by bicycle, which MSU Recycling calculated to result in a savings of 576 lbs. of CO_2 over using a box truck to travel a similar distance. Once collected, carbon material is mixed in with the organic waste, which then decomposes into finished compost. The finished compost is available for purchase at the Surplus Store.

7 Library Materials

MSU Surplus Store and the library work together to either reuse or recycle 100 % of the material withdrawn from the library collection. Reuse is the highest priority as that has the greatest environmental benefit (Thomas 2011). Deaccessioned volumes are removed from the shelves and processed for removal from the catalog before being loaded into hampers for collection. Surplus Store employees pick up the hampers and transport them to the recycling center, where significant time and resources go into ensuring each item receives consideration for reuse.

Each item is scanned using the International Standard Book Number (ISBN) in order to determine its value. Higher value items are posted for sale online while low value items are sold in bulk at the Surplus Store. Items that were found to have no resale value are first available for donation. Organizations that have received donations of printed materials from the Surplus Store include local schools, prisons through the State of Michigan Department of Corrections, and Better World Books, a company that promotes reusing books through their own network of sales and international donations for education (Better World Books 2015). Books that are not donated are debound using the recycling center's hydraulic debinding machine, which cuts the pages to separate them from the book spine and binding. The pages and covers are then added to the paper and paperboard recycling, respectively. All MSU Library materials processed by MSU Recycling are either reused or recycled; no materials are sent to the landfill or incinerated.

The MSU Surplus Store and Recycling Center processes a significant amount of print materials each year. During the 2013–2014 fiscal year the library generated 53,052 lbs. of materials, while the community drop off site collected 89,810 lbs. During that same timeframe, book sales totaled $151,559.68 (all amounts in USD). The bulks sales from the on-campus Surplus Store produced $75,790.62 from 29,096 items sold, while the online sales generated $75,769.06 from 5100 items sold. According to calculations using the Environmental Protection Agency's Waste Reduction Model (WaRM), reusing these materials saved the equivalent of 621 tons of CO_2 emissions (2014). Similarly, by recycling the over 89 tons of paper and paperboard from the debound materials, the Recycling Center was able to reduce greenhouse gas emissions by the equivalent of 305 tons of CO_2.

8 Transportation

In late 2014, LEC and MSU Bikes launched a collaboration to provide a bicycle for use by library staff. LEC has arranged for the library to lease the bicycle from MSU Bikes on an annual basis. Along with the bicycle, the lease includes front and rear lights, fenders, a warning bell, and a U-lock with mount. MSU Bikes provides any necessary adjustments or maintenance for the bicycle or accessories as part of the lease agreement. The bicycle is available for library staff and faculty to use on official library business around campus. LEC produced the required documentation for utilizing the bicycle, including the policies and procedures for use, the agreement for use, and a theft/damage/maintenance form in addition to materials promoting the bicycle to staff for use.

When not in use, the bicycle is securely stored in a locked closet near the circulation desk. Reservations are required for use of the bicycle and can be made on the staff shared online calendar. Staff members inform the circulation desk staff of the reservation and the bicycle is then checked out for use. All staff members must provide their own helmet before receiving the bicycle and agree to follow campus bicycle ordinances as per the user agreement. As of the end of 2015 (slightly over one calendar year after the start of the program) the bicycle has been used 20 times, according to library circulation statistics. While this is an admittedly small total, the bicycle program is still in its developmental phase and LEC expects it will increase in use among library staff.

9 Energy Use

In 2012, MSU developed an Energy Transition Plan with the long-term goal being 100 % renewable energy on campus (2012). The first steps towards this goal outlined in the plan were to transition the power source at the on-campus T.B. Simon Power Plant from coal to natural gas. MSU also set targets for incremental increases in renewable energy and reductions in greenhouse gas emissions. An important part of the strategy for reducing emissions has been to improve the efficiency of buildings on campus, including the library.

As an older public building open 24 h and housing over 500 public computers, energy use at the library is consistently high (Arnold 2015). The library not only must maintain lights and heat for nonstop use, but very specific environmental conditions must also be maintained in order to provide optimal conditions for preserving the physical collection (Linden et al. 2012). Even so, energy use within the library is generally declining according to the MSU Energy Dashboard campus monitoring tool. The library's energy use declined from 195 thousand British Thermal Units per gross square foot (kBTU/gsf) in 2008 to only 48 kBTU/gsf in 2015 (Michigan State University 2015b). These energy savings can be traced back to several facility efficiency upgrades. During this time period, IPF staff partnered with library facility staff to install new and efficient air conditioning chillers, replace a subbasement electronic transformer with a more efficient model, convert select lighting fixtures and ballast units to LED, and install occupancy sensors to automatically shut off lighting in unused areas of the library (J. Hensley, personal communication, 01/13/2016). Additionally, the library held a series of seminars in the spring of 2014 for staff on reducing energy consumption. These seminars were led by an IPF Energy Educator and focused on practical ways that individuals can reduce energy use while working in the library.

The library is building on these successful energy reduction projects and is currently engaged in an opportunity to further reduce its energy consumption through the IPF Building Commissioning program. Building Commissioning is a process by which a building is analyzed for operations, functionality, and efficiency. The assessment was conducted in 2014 and the report included recommendations for improvements to the lighting and HVAC systems and improving the building envelope. Recommended projects include projections on savings in both energy use (measured in one million British Thermal Units (MMBTU)) and US dollars. A return on investment (ROI) estimation in years is also included in the recommendation report. MSU administration has approved funding for one recommended project in 2016 to upgrade the lighting system in the Main Library's East Wing. The energy savings from this project are estimated to be 3397 MMBTU with a ROI of 6.6 years. Additional projects will be considered for funding by the university in future years and provide opportunities for further energy reduction.

10 Lessons Learned

Sustainable development at MSU and in the library continues to be an ever evolving process, and lessons learned from past experiences can inform sustainability performance into the future. Successes at the MSU library include efforts to reduce waste among library staff, the 100 % diversion rate for materials deaccessioned from the collection, composting organic waste in the library, and building upgrades to reduce energy consumption. The gap between staff and student participation in engaging in sustainability activities is a primary challenge facing sustainability at the MSU Library. This is compounded by the fact that new student cohorts matriculate every year, resulting in a recurring need for sustainability education on campus. Improvements in student education, signage, and communication should result in improvements in overall recycling and composting rates among students (Kelly et al. 2006; Sussman et al. 2013), but that will continue to be an ongoing process.

Any library looking to develop a similar sustainability program must also confront the question of cost, which manifests itself in several ways. Costs for upgrading energy using systems within a single building like the Main Library are fairly straightforward, and have the potential to pay for themselves over time with reduced utility payments. These types of projects also have some of the largest impacts on energy use, yet they also require significant upfront support. Other costs include paying salaries and operating costs to handle and sort the materials withdrawn from the library collection. Strong institutional support for sustainability initiatives from within IPF, MSU, and library administrations is crucial to overcoming these costs associated with pursuing sustainable development.

11 Conclusion

LEC and the library have benefited greatly from the institutional support provided by MSU Sustainability, MSU Surplus Store and Recycling Center, and MSU Bikes. The intertwined history of the MSU Library and MSU Sustainability has led to a long and fruitful partnership between the organizations. Collaborations between university units demonstrate a commitment to the process of developing a resilient and sustainable campus now and into the future. Many of the programs described in this chapter could be replicated in libraries at other institutions as a template for sustainable development in academic libraries.

References

Alpi, K. M. (2000). *It's not easy being green: A survey of staff experiences with environmental issues in sci-tech and other libraries*. Issues in Science and Technology Librarianship (pp. 1–10). Spring.

Arnold, D. (2015). Reducing energy use in older large buildings. *ASHRAE Journal, 57*(1), 52–59.

Barlett, P. F., & Chase, G. W. (2004). *Sustainability on campus: Stories and strategies for change* (p. 337). MIT Press Cambridge.

Better World Books. (2015). *Better World Books*. http://www.betterworldbooks.com/info.aspx (Last accessed 18 Nov 2015).

Bookhart, D. (2012). Sustainability: Shifting definitions and evolving meanings. In J. Martin & J. Samels (Eds.), *The Sustainable University: Green goals and new challenges for higher education leaders* (pp. 83–92). The Johns Hopkins University Press Baltimore: MD.

DeLind, L., & Link, T. (2004). Place as the nexus of a sustainable future: A course for all of us. In G. Chase & P. Barlett (Eds.), *Sustainability on campus: Stories and strategies for change* (pp. 121–137). MA: The MIT Press Cambridge.

Eagle, L., Low, D., Case, P., & Vandommele, L. (2015). Attitudes of undergraduate business students toward sustainability issues. *International Journal of Sustainability in Higher Education, 16*(5), 650–668.

Environmental Protection Agency. (2014). *Waste reduction model (WaRM).* http://epa.gov/epawaste/conserve/tools/warm/Warm_Form.html. Last Accessed February 26, 2015.

Henk, M. (2014). *Ecology, economy, equity the path to a carbon-neutral library* (p. 150). ALA Editions Chicago.

Kaplowitz, M. D., Yeboah, F. K., Thorp, L., & Wilson, A. M. (2009). Garnering input for recycling communication strategies at a Big Ten University. *Resources, Conservation and Recycling, 53*(11), 612–623.

Kelly, T. C., Mason, I. G., Leiss, M. W., & Ganesh, S. (2006). University community responses to on-campus resource recycling. *Resources, Conservation and Recycling, 47*(1), 42–55.

Kranert, M., Gottschall, R., Bruns, C., & Hafner, G. (2010). Energy or compost from green waste? A CO_2 based assessment. *Waste Management, 30*(4), 697–701.

Le Ber, J. M., & Gregory, J. M. (2004). Becoming green and sustainable: A Spencer S. Eccles Health Sciences Library case study. *Journal of the Medical Library Association, 92*(2), 266–268.

Linden, J., Reilly, J., & Herzog, P. (2012). Research on energy savings opportunities in university libraries. *Library Hi Tech, 30*(3), 384–396.

Lindsay, G., Macmillan, A., & Woodward, A. (2011). Moving urban trips from cars to bicycles: Impact on health and emissions. *Australian and New Zealand Journal of Public Health, 35*(1), 54–60.

Michigan State University. (2012). *Energy transition plan*. http://energytransition.msu.edu/uploads/energy_transition_plan_final.pdf. Last Accessed January 25, 2016.

Michigan State University. (2014). *Sustainability report 2014 east lansing*. MI. http://sustainability.msu.edu/report/2014/#/. Last Accessed November 20, 2015.

Michigan State University. (2015a). *About recylcing*. http://35.9.51.48/index.php/about/. Last Accessed November 20, 2015.

Michigan State University. (2015b). *MSU energy dashboard.* http://energydashboard.msu.edu/#. Last Accessed December 22, 2015.

Michigan State University. (2015c). *MSU facts*. http://msu.edu/about/thisismsu/facts.html. Last Accessed January 26, 2016.

Michigan State University. (2015d). *MSU surplus store*. http://guidebook.divert.msu.edu/view/22. Last Accessed November 20, 2015.

MSU Library. (2015a). *Library facts*. http://www.lib.msu.edu/about/libfacts/. Last Accessed December 23, 2015.

MSU Library. (2015b). *Our history*. http://www.lib.msu.edu/about/history/. Last Accessed December 22, 2015.

MSU Sustainability. (2015). *Spartan EcoReps*. http://bespartangreen.msu.edu/ecoreps.php. Last Accessed December 17, 2015.

Ohashi, T., & Shimoda, Y. (2014). Energy saving strategy of large-scale university facilities. *ASHRAE Transactions, 120*(1), 1–8.

Rowley, J. (2006). Libraries and environmental management. *Library Management, 27*(4/5), 269–279.

Sussman, R., Greeno, M., Gifford, R., & Scannell, L. (2013). The effectiveness of models and prompts on waste diversion: A field experiment on composting by cafeteria patrons. *Journal of Applied Social Psychology, 43*(1), 24–34.

Thomas, V. M. (2011). The environmental potential of reuse: An application to used books. *Sustainability Science, 6*(1), 109–116.

Toor, W., & Havlick, S. (2004). *Transportation and sustainable campus communities*. DC: Island Press Washington. p. 293.

Author Biography

Eric Tans holds a Master of Library and Information Science degree from the University of Pittsburgh. He is currently the Environmental Sciences Librarian at Michigan State University, where his research interests focus on sustainability in libraries.

Becoming Sustainable in Our Own Way: Sustainability at the Flagship Massachusetts Public University

Ludmilla Pavlova-Gillham and Dennis Swinford

Abstract

Planning for sustainable development at higher education institutions occurs throughout the US and the world, aided by environmental and climate change public policy and comprehensive sustainability assessment systems, such as the Association for Advancement of Sustainability in Higher Education's Sustainability Tracking, Assessment and Rating System (STARS). However, campuses often struggle to integrate policy goals into their strategic and physical plans, as well as into research, education, student life, operations and outreach efforts. This paper presents a case study of the comprehensive sustainability efforts undertaken by the University of Massachusetts Amherst and evaluates its progress by applying Kotter's 8-step approach to change management to multiple phases of the campus development efforts. Emphasis is placed on efforts to integrate sustainability goals with campus master planning, facility plans, green building policies, governance, teaching, research, and operations initiatives. The paper outlines concrete steps for comprehensive physical planning that universities may consider as they integrate change management practices for sustainable development into their campus' vision of sustainability.

Keywords

Master plan · Sustainable development · STARS · LEED · ACUPCC · Higher education · Case studies

L. Pavlova-Gillham (✉)
Campus Planning, University of Massachusetts, 360 Campus Center Way,
Amherst, MA 01003, USA
e-mail: lpavlova@umass.edu

D. Swinford
Campus Planning, Massachusetts Institute of Technology,
NE49-3131G Massachusetts Avenue, Cambridge, MA 02139-4307, USA
e-mail: swinford@mit.edu

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_7

1 Introduction: Campus Planning and Sustainable Development at Higher Education Institutions (HEIs)

Higher education institutions (HEIs), like many governments, corporate entities and organizations, are increasingly driven by their internal and external stakeholders to demonstrate their contribution to a sustainable society. Over a dozen years ago Anthony Cortese appealed to HEI planners for a cross-disciplinary planning process that involves students, faculty and staff as an integral part of educational practice and partners with collaborators in local and regional communities and with HEI staff on operational functions to make decisions and take actions for Sustainable Development (SD) (Cortese 2003). Municipal comprehensive planning—and more specifically HEI master planning—has a long tradition of developing physical plans for community growth in a manner that considers economic, environmental and social impacts (SCPEA 1928).

This paper provides a case study of SD practices at the University of Massachusetts, Amherst (UMA) as seen through the lens of organizational change management for sustainability and with a focus on physical planning and reductions of greenhouse gas (GHG) emissions driven by economic policy. Emphasis is placed on the institution's efforts to integrate sustainability goals with campus master planning, facility plans, green building policies, governance and educational and operations teaching and research initiatives.

2 Methodology

Kotter's process for leading change (Kotter 2012, p. 23) and previous case studies outlining phases of sustainability at HEIs (Krizek et al. 2011) (Sharp 2009) (Newman 2007) are used to map SD at UMA from 2001 to 2015 and to reflect on the engagement of campus stakeholders in meeting the challenges of GHG emission reductions. The authors used a qualitative approach by reviewing available public documents, conducting semi-structured interviews with administrative staff and faculty across the organization (Facilities and Campus Services, Chancellor's Sustainability Committee) to assess the effects of sustainability policy on total campus GHG emissions reductions. Both authors have been critically involved in the progression of sustainability at UMA and have arrived at lessons learned through critical reflection on the campus experience.

3 Case Study Theoretical Approach

A critical literature review of organizational change management theory (Todnem By 2005) reveals three general models of strategic change—managerial (manager-as-change-agent), emergent (employee-as-change-agent) and scale-based.

Given that colleges and universities are unique organizations (Manning 2012), an emergent model such as Kotter's eight-stage process of creating major change (Kotter 2012, p. 23, Fig. 2-2) was chosen as a yardstick for evaluating progress at UMA because of its practical guidance to organizations and managers and its application to grassroots as well as top-down approaches. Kotter notes that mature organizations often have over-managed and under-led corporate cultures that are experiencing both internal and external pressures to transform quickly. He proposes eight linear steps for major change management, the first four of which eliminate barriers prevalent in the status quo, the next three introduce new/changed practices, and the last embeds the changes in the institutional culture (see Fig. 1).

In addition, case studies on SD in HEIs such as University of Colorado Boulder (Krizek et al. 2012), Yale (Newman 2007), and Harvard (Sharp 2009) revealed a pattern of development in stages roughly corresponding to the following:

Phase I: grassroots/awakening—associated with grassroots and ad hoc activities and programs that lead to operational improvements and position the issue of sustainability as a point of importance for the organization by establishing a change management role (e.g. sustainability officer), a committee or task force and a series of pilot projects

Phase II: executive acceptance/pioneering—associated with a new level of institutional support for the business case for sustainability as it relates to multiple system improvements and green branding/public relations programs, and extending it to multiple entities (i.e. academic affairs, research, athletics, external relations as well as operations), though cost and economic terms still guide most decisions

Phase III: visionary leadership/transformation—in which campus leaders and highest level executives openly promote the sustainability vision and

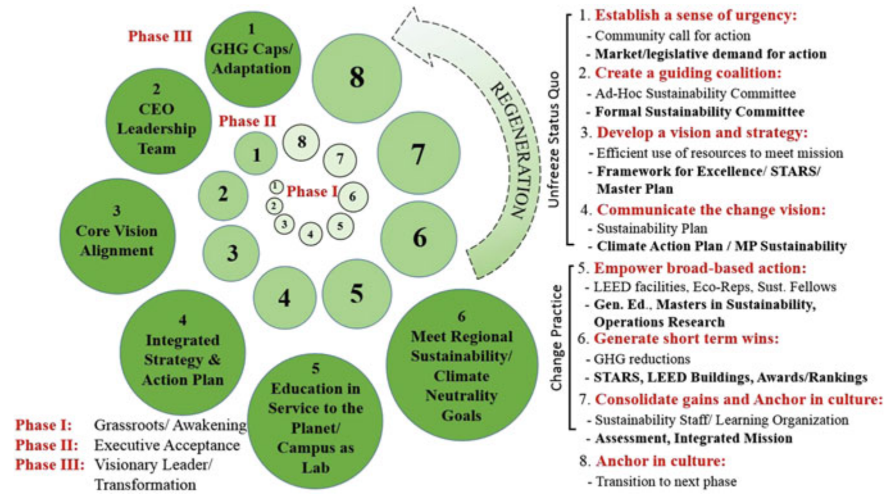


Fig. 1 Kotter's eights steps as applied to UMA stages of sustainable development

integrate new organizational processes and structures into the primary functions and desired outcomes of the institution.

The authors reflect on UMA's experience by applying these two frameworks as a way of understanding progress in adopting SD and environmental policy into its core activities.

4 University of Massachusetts Amherst

UMA is a nationally ranked public research university that is the flagship of the five-college University of Massachusetts system. Located in Amherst, the campus sits on nearly 1450-acres in the scenic Pioneer Valley of Western Massachusetts, 90 miles from Boston and 175 miles from New York City. The campus provides a rich cultural environment in a rural setting close to major urban centers. UMA is governed by a Board of Trustees and the legislature of the Commonwealth, and is home to 3 labor unions. It has a diverse community of approximately 28,300 students, 14,000 of whom live on campus and are supported by an extensive infrastructure of physical and social systems, a general impression of which is provided in Fig. 2.

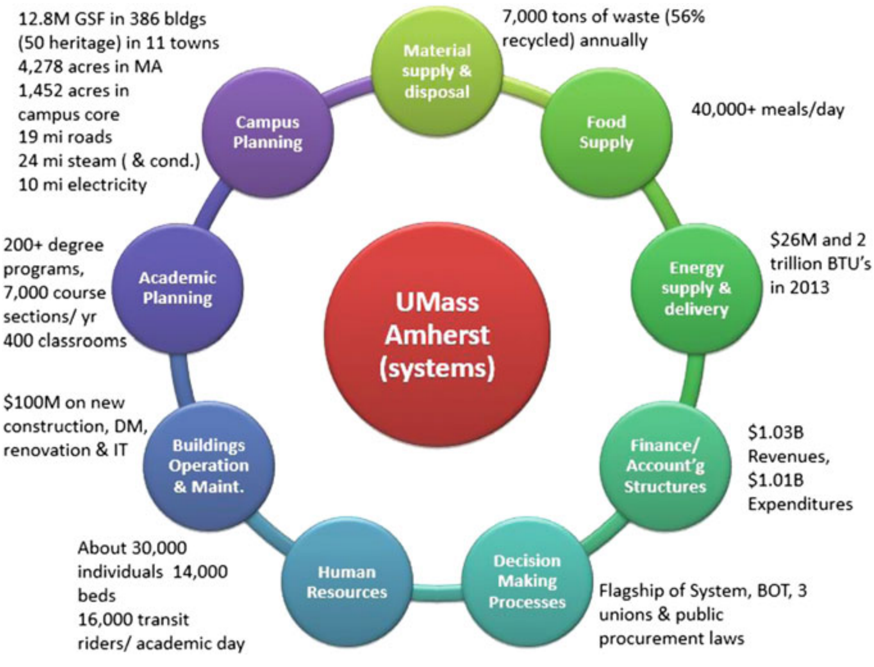


Fig. 2 UMass Amherst systems

UMA's history is firmly anchored within the environmental traditions of the Commonwealth of Massachusetts. Established in 1864 with funds from the Morrill Land Grant Act as the Massachusetts Agricultural College, it prides itself on being a leader in sustainable agriculture, food production and environmental conservation for 150 years. However, during the 1950–1970s the campus enrollments grew exponentially and the campus transformed from an agricultural college to a nationally ranked public research university and underwent a significant physical transformation from rural to semi-urban population density with a daily population of approximately 32,000 (Swinford et al. 2012) that ranks as having the highest energy use of all state agencies.

5 SD at UMA Phase I: Grassroots/Awakening 2001–2007

This phase of development at UMA can be seen as evolving a process, governance structures and internal leadership for SD.

Establishing a sense of urgency: In the 1990s students and faculty on the UMA campus became increasingly organized in advocating for support for SD, spurred by the example of HEIs who had endorsed The Talloires Declaration (ULSF 1990). The University of Massachusetts President's Office introduced a system-wide initiative that was being spearheaded by the UMass Boston campus and supported by the Urban Harbors Institute, the Massachusetts Executive Office of Environmental Affairs, and the New England Region of the U.S. Environmental Protection Agency. Simultaneous external and internal pressures in the academic community provided the impetus for elevating sustainability as a topic for institutional consideration.

Creating a guiding coalition: In response to this grassroots advocacy, in 2001 the Faculty Senate established an Ad Hoc Committee on Sustainability that was charged to assess sustainability activities on campus, evaluate programs on other campuses, and to develop a set of recommendations for future actions. The committee's members included faculty representatives from each school and/or college, directors of the Environmental Science department and the Environmental Institute, student advocates and administrative representatives from major business units.

Developing a vision and strategy: The committee and its taskforces met over the course of a year, attempting to develop a consensus on the need for further action with a goal of completing recommendations by the fall of 2002. An early report indicated the committee found a strong consensus that, "in the context of the university, sustainability is about using resources most efficiently to meet the mission of the university" (Goodwin 2001). It listed an impressive number of student, curriculum and operations efficiency projects that aimed at reducing carbon emissions by switching to cleaner fuels and co-generation of power and steam, implementing transportation demand management, achieving a 53 % recycling rate, and implementing an energy management system. Collaborative partnerships with other state agencies were being developed to fund recycling waste effluent and to initiate energy efficiency projects via a performance contract with an energy services company. A proposal for the development of a sustainability curriculum was prepared through the collaborative efforts of students, faculty and community members, as well as a proposal to adopt the U.S. Green Building Council's Leadership in Energy and Environmental Design™ (LEED) standard for new construction projects. Having listed these early successes which could result in as much as 30 % reductions in GHG emissions, and under the pressure of significant system-wide budget cuts in 2002 that lead to the loss of faculty positions, the Ad Hoc Committee did not submit any formal proposals and was disbanded.

Additional informal activities and impact of environmental policy: The failure of this early attempt at integrating SD into the University mission of teaching, research, and service was nevertheless followed by steady progress within individual units. The New Construction and Renovation subcommittee re-branded itself as the Green Building committee and incorporated "Responsible Use of Energy and Natural Resources" guidelines within the UMA Construction Design Guidelines (Hatch 2004)—and the first Sustainability Plan (Fitzpatrick 2005) was written in compliance with state legislation (EO 438 2002).

The department of Environmental Conservation introduced three sustainability courses and a Sustainable Food and Farming program. Its graduates produced research projects that proposed, funded and piloted two very successful student initiatives: a Permaculture program on campus that engaged the support of Dining Services and an Eco-Rep program within Physical Plant.

In 2007 University of Massachusetts System President Jack M. Wilson made a comprehensive SD commitment by signing the five UMass campuses onto the Second Nature American College & University Presidents' Climate Commitment (ACUPCC 2006), thus ending the grassroots/awakening phase of UMA change toward SD and initiating the next phase of campus sustainability work.

6 SD at UMA Phase II: Executive Acceptance/Pioneering 2008–2014

In 2008 Interim Chancellor Thomas Cole established an Environmental Performance Advisory Committee (EPAC) to develop a Climate Action Plan (CAP) and implement campus sustainability projects. This phase of development at UMA can be seen as building on the governance structures and internal leadership established in Phase 1 and evolving a research and data gathering process for advancing SD activities.

Establishing a sense of urgency: A Princeton Review survey (Ifran 2011) reported that 69 % of prospective college students say that a college's green initiatives have a direct impact on their decision to attend. This clear market signal and a series of legislative actions set the context for UMA to take greater steps in addressing GHG emissions. Gov. Deval Patrick's (EO 484 2007) created a Leading by Example (LBE) program that set new performance targets and reporting requirements for GHG emission reductions, energy conservation and efficiency, renewable energy, green buildings, and water conservation in facilities owned and operated by state agencies (LBE 2007); and the Global Warming Solutions Act (GWSA 2008) regulations were incorporated into the Massachusetts Environmental Policy Act (MEPA), requiring agencies to provide "meaningful opportunities for public review of the potential environmental impacts of Projects", and to administer a review process that requires documentation of environmental impacts and assessment of alternatives and mitigation measures (MEPA 2013).

Developing a sense of urgency in connection with these regulatory requirements, however, proved challenging due to the advent of the global financial crises in 2008–2009 and the success of two important initiatives: an extensive energy conservation program and the completion of an award winning co-generation Central Heating Plant, which resulted in approximately 30 % reductions in GHG emissions.

Creating a guiding coalition: Sustainability activities developed under the guidance of EPAC from 2008 to 2012 and a re-branded Chancellor's Sustainability Committee (CSC) from 2008 to 2015 that included a two-tiered organization with an executive committee comprising of unit managers from across the university system, and volunteer driven implementation sub-committees focused on sustainability systems (including green building, residential programming, education and research, food system, and master planning). Support from upper level administrators was evident in the hiring in 2011 of three full time Sustainability staff in Physical Plant, University Relations, Auxiliary Services and a Director of Academic Sustainability Programs. In addition, four part-time graduate research positions were established within Facilities/Campus Planning to develop tools and analysis in support of green buildings and the campus sustainability initiative.

A strategic plan developed by Chancellor Holub, *Framework for Excellence* (Holub 2009), triggered a parallel effort for facilities and master planning for growth. It was steered by Campus Planning with the support of external consultants and the engagement of multiple campus entities, including campus and community committees, the Chancellor's Leadership team and the Faculty Senate. In 2009 UMA hired a Campus Planning Director to develop a traditional Campus Master Plan (CMP) and use the process to articulate in physical terms the benefits of the development program and inspire donors and the greater community to fulfill the strategic vision.

Developing a vision and strategy: In 2009 consultants for the energy conservation program facilitated a strategic planning event involving over 50 community members from across the ranks of students, faculty and staff developed a wish list of objectives to pursue over the next 10 years. Volunteers on eight subcommittees organized to write the first CAP (Stoffel and Parkin 2010). In 2011 a collaborative team of EPAC members (students, staff, and faculty) assessed campus progress by submitting a Sustainability Tracking Assessment Rating System (STARS) report to the Association for the Advancement of Sustainability in Higher Education

(AASHE), which received a Gold rating—one of only 24 college and university campuses nationwide to receive this rating at the time. Two years later the newly hired Campus Sustainability Manager published an updated CAP v.2 that leveraged the STARS framework goals and presented a comprehensive plan with three focus areas and specific implementation strategies associated with education/engagement, energy/emissions/buildings and funding (Small 2012).

Concurrently, the UMA CMP (Swinford et al. 2012) was created in an open and inclusive process that used typical public participation tools such as stakeholder meetings, public charrettes, and open forum meetings. This process was critical to gain wide support for capital development from within the community—both on- and off-campus. The steps in creating the content for the plan closely followed a typical process for campus master planning that took approximately three years and nearly 200 events over 2 years to complete. A blended team of professional consultants and campus planning staff gathered data on the campus environment, utilities and transportation, hosted vision development sessions with stakeholder groups, and collected space planning efforts into future facility requirements aimed at the near term (2020 vision) and long term (potential capacity development 2050 and beyond). The team created alternative solutions to meet the vision and strategic planning goals, accommodate the program, and test the land use, density, transportation, building condition and program assumptions. It presented a draft plan for review and comment by the campus community and additional stakeholder meetings, including online engagement with over 3,500 visitors. The final CMP document and GIS model described a long term physical framework for systems such as open space, circulation, utilities, transportation and parking, identified sites and general uses for future facilities and established key landscapes to be conserved. During the process, UMA created Guiding Principles that served as a link to other UMA policies and embodied the smart growth principles: to establish a long-term 50 year perspective; create growth opportunities in the campus core; form an open space framework; build Campus not just buildings; untangle vehicular and pedestrian circulation conflicts; develop a 24/7/12 mixed use campus core; unify the academic campus; and respect planning and building heritage.

<u>Communicate the change vision</u>: The Sustainability Initiative and CMP efforts contributed to a community-wide enterprise that elevated the academic stature of the institution, enhanced the brand and reputation of UMA and aspired to efficiency and cost savings. Multi-media communication campaigns under the slogans "Learn, Live, Lead: Sustainable UMass" and "Building Campus and a Culture of Planning" were aimed at both internal and external stakeholders, articulating the vision and providing resources and connections to support their implementation.

In addition, the campus undertook an extensive analysis of the future environmental and GHG impacts of the CMP and met its obligations to communicate these impacts to the community by submitting a comprehensive Expanded Environmental Notification Form for the University's 2012–2021 Capital Improvement Plan to the EOEEA's Massachusetts Environmental Policy Act Office (MEPA) (Vigneau et al. 2013).

6.1 Empower Broad-Based Action

The Sustainability Initiative developed multiple activities aimed at inspiring behavior change and empowering students, staff and faculty to take individual and group actions. Highlights of these include: (i) student activities such as the Eco-Rep program, Sustainability Fellows developing operational policy and activities, green events, New2U reuse collection and tag sale, waste reduction at athletic events and electronic waste recycling; (ii) a sustainability course finder, a sustainability curriculum initiative that awards faculty fellowships to develop new curriculum, new Masters of Science programs in Environmental Conservation, Sustainability Science and Design and Historic Conservation, and a community knowledge archive; and (iii) a green office program, a sustainability innovation and engagement fund, and the permaculture initiative.

The Green Building Committee established a green building program to assist UMA project managers in understanding how the LEED system supports SD at the campus systems level and to communicate campus environmental information to outside design teams so that UMA can comply with and go beyond the requirements of (EO 484 2007). It published its first Green Building Guidelines associated with LEED v3 in 2011, with an updated version in 2013 (Pavlova-Gillham et al. 2013) that includes a requirement for post-occupancy measurement and verification of actual performance. As of the end of 2015, UMA completed seven LEED projects (one of them a complex of 6 residential buildings) that constitute 394,196 square feet of LEED space certified at the Gold level and 512,485 square feet certified at the Silver level, representing 7 % of all campus gross area and supporting about 2300 occupants. With nine additional projects that are registered and undergoing certification, the projected LEED certified space at the end of 2018 will constitute 12.4 % of the total GSF on campus.

The Master Plan Sustainability (MPS) subcommittee was established in 2013 as part of the CSC to compile a comprehensive summary of the sustainability approach to all of the campus physical systems in a manner that would integrate with the emerging sustainability vision of the Chancellor's Sustainability Committee (Pavlova-Gillham et al. 2015). It produced a final MPS chapter that communicated the UMA approach toward sustainable development by assembling a comprehensive review of previous reports, plans and initiatives to assess campus environmental performance, project the impact of growth on increased GHG emissions (Fig. 3), and identify measurable actions aimed at reducing their impact.

Generating short term wins: UMA and the Sustanability Initiative achieved significant gains by being designated as a STARS Gold institution (both v1 and v2); it ranked 21st in Princeton Review's list of top 50 Green Colleges; the permaculture program won the White House's 2012 Campus Champions of Change Challenge and UMA was acknowledged for its efforts by being awarded the 2014 ACUPCC's Climate Leadership Award. The CMP also achieved success by being endorsed by the Faculty Senate, by receiving approval from the Secretary of Energy and Environmental Affairs and positive press from local communities, including an award from the Western Massachusetts American Institute of Architects. In

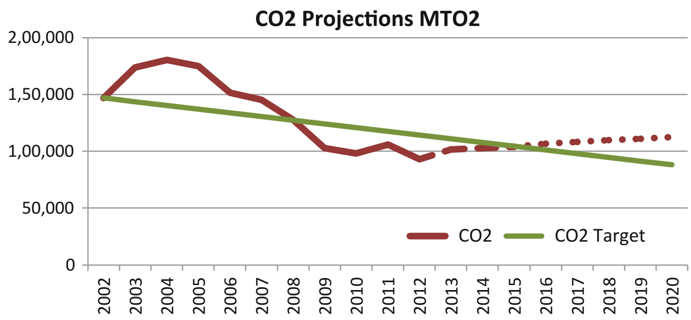


Fig. 3 UMA GHG Emissions projections—capital plan 2020

addition, the mission alignment of education, research and operations is directly contributing to sponsored sustainability research by leveraging the data-rich campus environment and GIS model of future growth to develop tools for SD analysis (Mostafavi et al. 2014, 2015; Tabatabaee et al. 2015).

Consolidating gains and anchoring new approaches in the culture: UMA is working with the UMass President's Office to develop a sustainability policy that will demonstrate leadership and commitment to SD and establish a framework for sustainability management across the 5 college system. In addition, the CSC was disbanded and a new Chancellor's Sustainability Advisory Committee has been organized to advise the Chancellor and his Leadership Council on all sustainability issues and activities related to UMA, and to coordinate campus sustainability efforts across all relevant departments of the university. This will effectively initiate a new phase in leadership for SD.

7 Conclusions for University Sustainable Development

UMA's experience with SD over a dozen years, evaluated within an organizational change framework, yields some conclusions that can help other HEIs to align their institutional mission with environmental policy goals and become sustainable in their own way. Following are the most important conclusions that were discovered during this critical analysis of UMA efforts in becoming sustainable:

7.1 Process, Governance and Internal Leadership

In the initial stage of the SD effort UMA had not developed a systemic approach to institutional governance and a process that included the campus community. Although administrative decisions evidenced commitment to SD practices and significant investment in energy efficiency and delivery that reduced GHG emissions, the early effort at UMA focused upon creating process and governance. Some critical lessons learned from the physical planning perspective are:

- Implement a comprehensive planning process that integrates strategic, academic, financial and physical plans, and is repeated at least every five years in concert with capital plans.
- Insist on an inclusive and transparent process. Sustainability is a community effort and everyone has to understand how and where they fit into the process.
- Integrate SR systems such as ACUPCC, STARS and LEED with executive, financial, capital development, and operational management practices to support the specific strategic goals of the HEI.
- Provide continuity and consistency with one authority for SD decisions.
- Develop responsibility, accountability and incentive structures to support progress towards sustainability goals.

7.2 Research and Data

As the SD effort at UMA continued to mature it became critical to account for and communicate the success of the abstract and challenging concept of sustainability. Establishing teaching and research programs within the academic structure attracted researchers and students to the institution. The institutional leadership team and sustainability advocates need data to compare and understand the effectiveness of policies and actions to meet established SD goals. Critical actions for conducting research and gathering data to support SD are:

- Create robust cross-departmental engagement to identify important questions or issues early on in the decision making process and include specific sustainability goals and requirements for capital projects.
- Establish a rigorously applied carbon budget for campus development. Develop enterprise data sets that allow the identification and maintenance of information about academic programs, space assets, operations and related energy/carbon emissions at a level of detail (at minimum at the building level) that is meaningful for decision making in capital, financial and carbon budget planning.
- Leverage the academic endeavor in using the campus as a learning laboratory to tie together academic research and teaching with operations research and sustainability work on campus.

7.3 Leadership for Society

As the efforts at UMA continue to mature the climate crisis demands that HEIs demonstrate leadership for today's society—they must teach themselves and tomorrow's leaders how to integrate sustainability into every decision and action in order to achieve tangible environmental improvements. Critical actions that emerge from reflection on UMA's experience are:

- Recognize that a partial commitment to SD is not enough to solve the climate crisis or reach GHG emissions reduction goals.
- Model governance/negotiation strategies to resolve the conflicts inherent in reducing consumption, living and practicing within set limits of growth.
- Lead efforts to conserve natural resources by placing local/institutional decisions into a regional/global framework.
- Lead resiliency planning efforts with multi-disciplinary knowledge and modeling predictions that utilize the campus/state as a laboratory for applied research into a variety of policies.
- Practice what is taught by leading the change effort to connect academic and physical planning toward meeting the triple bottom line.

References

ACUPCC. (2006). American College & University Presidents Climate Commitment. Second Nature. http://www.presidentsclimatecommitment.org/. Last accessed January 29, 2016.

Cortese, A. D. (2003). The critical role of higher education in creating a sustainable future. *Society for College and University Planning: Planning for Higher Education Journal, 31*(3), 15–22. http://www.aashe.org/resources/pdf/Cortese_PHE.pdf. Last accessed January 29, 2016.

EO 438. (2002). Swift, Jane. Executive order 438. State sustainability program. Commonwealth of Massachusetts. http://www.mass.gov/courts/docs/lawlib/eo400–499/eo438.txt.

EO 484 (2007). Patrick, Deval. Executive order 484. Leading by example: Clean energy and efficient buildings. Commonwealth of Massachusetts. http://www.mass.gov/anf/docs/dcam/dlforms/energy/energy-eo484-final.pdf. Last accessed January 29, 2016.

Fitzpatrick, B. (2005). UMass Amherst sustainability plan. Sustainability reports and plans. Paper 11. http://scholarworks.umass.edu/sustainableumass_reportsplans/11/. Last accessed January 29, 2016.

Goodwin, S. (2001). Status report of the ad hoc committee on sustainability. Faculty senate doc. No. 02-044. University of Massachusetts Amherst. May 9, 2001.

GWSA. (2008). Chapter 21N: Climate protection and green economy act. Global warming solutions act of 2008. Massachusetts General Laws. https://malegislature.gov/Laws/SessionLaws/Acts/2008/Chapter298. Last accessed January 29, 2016.

Hatch, J. (2004). Responsible use of energy and natural resources. In *Construction design guidelines. Design and construction management*. MA: University of Massachusetts Amherst http://www.umass.edu/dcm/sites/default/files/u31/Construction_Design_Guidelines10-04.pdf. Last accessed January 29, 2016.

Holub, R. (2009). *Framework for excellence: Vision, mission, goals*. MA: University of Massachusetts Amherst. https://www.umass.edu/chancellor/sites/default/themes/chancellor/css/theme/images/framework-vision.pdf. Last accessed January 29, 2016.

Ifran, U. (2011). More colleges adding 'green' to school colors. *New York Times*, August 16, 2011.

Kotter, J. P. (2012). *Leading change*. Boston: Harvard Business Review Press. 2012.

Krizek, K. J., Newport, D., White, J., & Townsend, A. R. (2012). Higher education's sustainability imperative: How to practically respond? *International Journal of Sustainability in Higher Education*, *13*(1), 19–33.

LBE. (2007). Leading by example: Background—State clean energy and efficient buildings. MA Executive Office of Energy and Environmental Affairs. http://www.mass.gov/eea/grants-and-tech-assistance/guidance-technical-assistance/leading-by-example/leading-by-example.html. Last accessed January 29, 2016.

Manning, K. (2012). *Organizational theory in higher education*. Routledge.

MEPA. (2013). Massachusetts environmental policy act (MEPA). MA Executive Office of Energy and Environmental Affairs. http://www.mass.gov/eea/agencies/mepa/. Last accessed January 29, 2016.

Mostafavi, N., Farzinmoghadam, M., & Hoque, S. (2015). Envelope retrofit analysis using eQUEST, IESVE Revit Plug-in and Green Building Studio: A university dormitory case study. *International Journal of Sustainable Energy, 34*(9), 594–613.

Mostafavi, N., Farzinmoghadam, M., Hoque, S., & Weil, B. (2014). Integrated urban metabolism analysis tool (IUMAT). *Urban Policy and Research, 32*(1), 53–69.

Newman, J. (2007). An organisational change management framework for sustainability. *Greener Management International, 2007*(57), 65–75.

Pavlova-Gillham, L., Mendoza, T., Small, E., O'Flaherty, P., Mostafavi, N., Farzinmoghadam, M., et al. (2013). UMass Amherst green building guidelines 2013. Campus Planning reports and plans. Paper 3. https://scholarworks.umass.edu/cp_reportsplans/3. Last accessed January 29, 2016.

Pavlova-Gillham, L., Mostafavi, N., Farzinmoghadam, M., Landrey, K., Pozveh, S. T., Small, E., et al. (2015). UMass Amherst campus master plan sustainability chapter. Campus Planning master plans. Paper 5. http://scholarworks.umass.edu/cp_masterplans/5. Last accessed January, 29, 2016.

SCPEA. (1928). Hoover, Herbert. Standard city planning enabling act. U.S. Department of Commerce. American Planning Association 2015 https://www.planning.org/growingsmart/enablingacts.htm. Last accessed January 29, 2016.

Sharp, L. (2009). Higher education: The quest for the sustainable campus (Editorial). *Sustainability: Science, Practice, and Policy*, *5*(1). http://sspp.proquest.com/static_content/vol5iss1/editorial.sharp-print.html. Last accessed January 29, 2016.

Small, E. (2012). UMass Amherst climate action plan 2.0. Sustainable UMass. Paper 3. http://scholarworks.umass.edu/csi/3. Last Accessed January 29, 2016.

Stoffel, J., & Parkin, B. (2010). UMass Amherst climate action plan. Sustainable UMass. Paper 1. http://scholarworks.umass.edu/csi/1. Last Accessed January 29, 2016.

Swinford, D., Pavlova-Gillham, L., LaCour, N., Raine, S., Stepanov, A., Ayers Saint Gross, et al. (2012). University of Massachusetts Amherst campus master plan 2012. Campus Planning. Master Plans. Paper 1. http://scholarworks.umass.edu/cp_masterplans/. Last accessed January 29, 2016.

Tabatabaee, S., Weil, B., & Aksamija, A. (2015). Negative life-cycle emissions growth rate through retrofit of existing institutional buildings: Energy analysis and life cycle assessment of a case study of university dormitory renovation. Student Showcase. Paper 12. http://scholarworks.umass.edu/sustainableumass_studentshowcase/12. Last accessed March 1, 2016.

Todnem By, R. (2005). Organisational change management: A critical review. *Journal of Change Management, 5*(4), 369–380.

ULSF. (1990). In *Report and Declaration of the Presidents' Conference*. Talloires, France: University Leaders for a Sustainable Future. http://www.ulsf.org/programs_talloires_report.html. Last accessed January 29, 2016.

Vigneau, D., Holler, J., University of Massachusetts Building Authority, Mathews, J., Pavlova-Gillham, L., & Small, E. (2013). University of Massachusetts Amherst 2012–2021 capital improvement projects. Campus Planning. Master Plans. Paper 3. http://scholarworks.umass.edu/cp_masterplans/3. Last accessed January 29, 2016.

Author Biographies

Ludmilla Pavlova-Gillham AIA, LEED BD+C is a Senior Campus Planner at University of Massachusetts Amherst, where for 17 years she has worked as a capital project manager and campus planner for major capital projects and comprehensive studies over $200 M. As an Adjunct Professor in Building Construction Technology she taught Project Management for Sustainable Design and Construction and works with academic interns on sustainability related operations research projects. Prior to coming to UMass she was in private practice in New York City as designer of national and international commercial and institutional projects.

Dennis J. Swinford ASLA, is the Director of the Office of Campus Planning at the Massachusetts Institute of Technology. Prior to this position Dennis was the Director of Campus Planning at The University of Massachusetts Amherst and a Principal Project Planner at Harvard University's Allston Development Group. Before joining the institutions he was in private practice for 25 years, providing planning and design expertise to over 35 different national and international institutions.

Identifying Relevant Versus Received Sustainability Education at Industrial Engineering and Management Programs

Niccolas Albiz

Abstract

Implementing and evaluating sustainable development in higher education poses particular difficulties, as the field remains contested. This paper presents an innovative approach to understanding the current sustainability education at university programs and envisioning its desired future state. This approach is based on the convergence seen in current scientific literature within the field. This study utilized this method on Sweden's five largest industrial engineering and management programs (covering 74 % of the particular population), involving 111 interviews and resulting in identification of the relevant sustainability content and mapping of the received content at these programs. This paper documents the process-oriented, as supposed to results-oriented, approach used, as well as certain key results and insights. The revealed adoption challenges were structured according to their interconnectedness, allowing points of high leverage to be found for future interventions. This paper is appealing to all who wish to conduct pre-studies to engaging in developing program curricula at larger scale through collaboration between various universities. The paper will outline the process, the key success factors (as identified by the author) and the insights that have a bearing on a broader audience than industrial engineering faculty.

Keywords

Sustainability · Competencies · Education · Methodology · Industrial engineering

N. Albiz (✉)
Department of Industrial Economics and Management, School of Industrial Engineering and Management, Royal Institute of Technology (KTH), Brinellvägen 68, 10044 Stockholm, Sweden
e-mail: niccolas@kth.se

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_8

1 Introduction

Sustainability is increasingly more relevant to all practical fields of study, particularly engineering (Carew and Mitchell 2007). This study's relevance is based on the belief that the increasing importance of these considerations is noticeable in the roles with which industrial engineers will contribute to the future, namely business development, product development and management. UN Global Compact and Accenture revealed, in 2013, that 93 % of the 1000 surveyed CEOs (from 27 industries across 103 countries) consider sustainability as important or very important for the future success of their business. The same study reports that 67 % of these believe that business is not doing enough to deal with the global challenges we are facing (UN Global Compact & Accenture 2013). These survey results, along with the clear ambitions set by the COP21 conference in Paris, suggest sustainability education to be of high relevance and urgency for these students to partake in.

In 2012–2013, a large national (Sweden), results-oriented, study was conducted, by Universitetskanslersämbetet (UKÄ) (governmental agency for assessment of higher level education), assessing the quality of all technical/engineering programs at Swedish universities. Overall, the 5-year industrial engineering and management programs (i-programs) (swe. civilingenjörsprogram) achieved a high standard (Universitetskanslerämbetet 2013). The criteria discussing sustainability and ethics was, however, not easily assessed (Strömberg 2015). It was concluded that societal and ethical topics were not broached to any significant degree (Universitetskanslerämbetet 2013).

The field of sustainability is at an early stage (Wiek et al. 2011), remaining contested (Carew and Mitchell 2007; Becker et al. 1999; Littig and Griessler 2005; Wals et al. 2015) and normative (Wiek et al. 2011; Lang et al. 2012; Mulder 2010; Dahlin 2014). Given these drivers of uncertainty and the status of sustainability as a multidisciplinary field (Byrne 2012; Hanning et al. 2010; de Vries and Petersen 2009), including sustainability education into a program curriculum is a difficult task.

Wiek, Withycombe and Redman argue for the existence of two interesting convergences existing in the literature on sustainability for higher education. Firstly, they discovered a convergence around the focus on key competencies and learning outcomes. Secondly, their study of the existing literature divulged a convergence on five such key competencies. These five key competencies were later organized into a framework showing how they interrelate, as well as impact the problem solving and research processes. The identified key competencies were labelled "Systems Thinking competency", "Anticipatory competency", "Normative competency", "Strategic competency" and "Interpersonal competency". These competencies go beyond that which pertains to ordinary problem solving, though the exact line between ordinary competencies and sustainability competencies is not well defined (Wiek et al. 2011).

This paper will be dedicated to describing the study's approach of interviewing for relevant sustainability content to a specific profile (comparing it to the key competencies framework) and then contrasting the recommended content to the received content at the programs. The paper will also shortly divulge the insights and some results from the study, as well as experienced key success factors to applying this methodology.

2 Method

2.1 Purpose and Aim

Wiek, Withycombe and Redman demonstrate some concretization within the field, yet it remains at a high level of abstraction. All the while, international studies show an urgent need for action and for these competencies within industry, e.g. the UN Global Compact-Accenture report.

The approach taken in this study intended to concretize the normative competency for a particular engineering group, industrial engineers. The normative competency was deemed a bottle-neck, being the most abstract and broad competency of the five.

The study consisted of identifying the relevant sustainability content (SC) for students of the five-year i-programs and contrasting it with the received sustainability content at these programs (a process-oriented study as supposed to UKÄ's results-oriented study). Two distinct phases can be identified, the first involved identifying the relevant content and the second involved relating this to the received education at the studied programs (the topics that were broached by lecturers in the courses).

Research paradigms should not be seen as discrete but as part of a continuum (Collis and Hussey 2009). This holds true for this study in particular, as each interview took a hermeneutic perspective resulting in empirical content to be interpreted (Jacobsen 2002) (particularly during the first phase). Yet, the large amount of quantitative data, with low uncertainty, received during the second phase encouraged a more positivistic approach to the second phase (Collis and Hussey 2009), whilst not releasing the interpretivistic approach entirely.

2.2 Delimitations

The programs included were Sweden's five largest, five-year industrial engineering and management programs, together covering around 74 % of the studied student population (Antagning.se 2015; Henningsson 2015). The universities giving these programs are Luleå Tekniska Högskola (LTU), Kungliga Tekniska Högskolan (KTH), Linköpings Tekniska Högskola (LiTH), Chalmers Tekniska Högskola (CTH) and Lunds Tekniska Högskola (LTH).

The first phase involved ten interviews with experts within different fields of sustainability, all from academia. The interviewees were of varied positions, varied educational backgrounds, genders, disciplines, institutions and varied ages, thus capturing multiple perspectives and reducing biases. The interviewee group included respected and renowned institutions and experts. Amongst these were the influential Stockholm Resilience Centre, Stockholm School of Economics, the Centre for Social Sustainability at Karolinska Institutet and others. Other indications of expertise included, a UNESCO chair in education for sustainable development, a Blue Planet prize and an Ashoka fellowship.

Lastly, when scanning the program content, in the second phase, only mandatory or conditionally elective courses (where a student is allowed to choose a course from amongst a limited set of preselected courses) were taken into consideration. Electives could not be said to naturally pertain to the programs.

2.3 Phase 1—Identifying Relevant Sustainability Content for Industrial Engineering and Management Students

The process for the first phase of the study included creating a coherent profile of the student body, interviewing the experts, synthesizing the input from the experts, requesting input from the interviewees on the concretization and finally refining the input into a content list.

All studies describing the i-programs and their alumni were read and synthesized, together with the national UKÄ-study, into a common profile for the particular student body. Key aspects of the profile were the "bridge-building" between disciplines (Universitetskanslerämbetet 2013), a prevalent leadership tendency amongst alumni, a vast range of industries that the alumni work within, and tasks relating to strategy and business development (Royal Institute of Technology 2007, 2010, 2011; Chalmers Technical University 2010; I-sektionens Alumnutskott 2011, 2012, 2013). These university-specific reports did not always achieve a representative sample size, yet taken together they gave a consistent image of the profile, which was confirmed by the program coordinators as being accurate.

Semi-structured interviews with open-ended questions followed by probing questions were used to ensure retrieval of valid qualitative data (Collis and Hussey 2009). The profile was given ahead of the interviews and at the start of each interview, such that the topics broached in the interviews would truly be relevant to the particular population. The input received was subsequently concretized through a repertory grid technique (Collis and Hussey 2009), which was modified so as to allow for a collective concretization that captures the interviewees' joint views and perspectives on the subject. The final layout and division of the concept was thus a result of the interviewees' manner of conceptualizing the subject.

The modification consisted in synthesizing the interview data into one cohesive mapping of topics (rather than one per interview). The final draft of the mapping was presented as a content list, rather than a nexus matrix, for increased readability and to facilitate the second phase of the study. As a consequence, some complexity was truncated. This was not deemed to be a problem as illustrating the interconnections between topics is primarily of importance during the implementation into curricula.

A significant convergence amongst the interviews was found, simplifying the synthesis. Interviews were conducted with a diverse set of experts, as such the resulting content list can be considered exhaustive, to the best of our current knowledge (Wals et al. 2015). From the qualitative data received during the interviews there was both explicit and implicit agreement with regards to content and approach. The final result was intended to define the normative competence more precisely, based on the industrial engineering profile. However, the interconnectedness of topics and of knowledge and skills suggests the concretization develops all five key competencies (given adequate implementation). The result of the first phase is well aligned with both the key competencies framework as well as the refined concretization of Sweden's national learning outcomes concerning sustainability in higher education (by KTH-Sustainability 2014), suggesting high reliability.

2.4 Phase 2—Mapping Received Sustainability Content in Industrial Engineering and Management Programs

The general process for the second phase consisted in interviewing the program coordinators of each of the studied programs, reviewing the course curriculums of the programs, interviewing course coordinators/lecturers and compiling the results. In total, 101 interviews were conducted within the second phase of the study, 5 with program coordinators and 96 with course coordinators (many of which were in charge of/involved in more than one course).

The program coordinators gave a good overview of the structure of each program, allowing for a more intelligent search of its content, as well as an initial indication of which courses had a high probability of broaching some form of sustainability content (SC). The programs were scanned and the courses evaluated as to having low, medium or high probability of including SC. Around 600 courses were scanned. Course coordinators were contacted and interviewed, commencing with the high probability courses and then the medium probability courses. The ranking was iterative and the interviewees were often asked (if it seemed likely they would know) who else covered SC in their courses.

2.4.1 The Interview Technique

Interviews were initiated with a description of the study, the interviewer's background, the purpose, the intention, the process and the reason as to why they were being contacted. It was deemed important as the study risked being perceived as an assessment of the interviewees. The rare times where a component of the initial briefing was missed led to a different tone in the interview, confirming the importance of that particular introduction. It was important to put the interviewee at ease from an ethical standpoint, and also as a measure of ensuring adequate data was retrieved. The interviews would otherwise be more susceptible to social desirability bias (SDB) (Lee 1993; Fisher 1993).

The description ensured them that *the project was being conducted independent of any project sponsor or organisation*, *the courses were not being evaluated on their own*, *the aim of the study was to display the SC in the programs for informative purposes and to encourage collaboration*, *all the challenges mentioned would be compiled anonymously*, and that *the interviewer had genuinely good intentions in conducting the study* (implicit rather than stated explicitly).

In the large majority of instances, a good rapport was established and the SDB minimized. The interviewer was aware of the possibility of skewed results from SDB and interpreted the results accordingly. Few methods have been universally effective to remove SDB (Nederhof 1985), yet through the use of non-threatening language (Lee 1993) and ensuring the interviewed of that they are not being assessed helped limit the SDB in this case (Fisher 1993). The interviewer employed probing questions concerning concrete events or concrete texts or tools used and when possible the interviewer asked indirect questions, to reduce the risk of SDB becoming an issue (Fisher 1993).

The interviews were, as in the previous phase, semi-structured and with open-ended questions (also as a manner of reducing the SDB). The interviews ranged between 5 and 75 minutes in length, depending on the course, with an average of 15–20 minutes. Most were conducted over the phone, with preceding email contact. The questions that were prepared beforehand were simply two, which were then followed by probing and clarifying questions:

> What sustainability content is covered (if any is covered) in your course/s?

The question was asked as it is and clarified if needed. No definition was given, instead the interviewee was asked, if they seemed perplexed, to base their answer on their own definition of sustainability. The purpose of this was two-fold. This approach ensured that that which was said was actually taught and communicated as sustainability (CSR/Responsible business practice were other labels used). The second benefit is that it reduced SDB by not providing a pre-defined range of answers/topics that one could seek to accumulate as many of as possible (Lee 1993). The formulation of the question gave deeper qualitative insight as to the interviewee’s view of the subject.

Further probing questions clarified the interviewee’s answers, the point being to achieve concrete information as to how the material was covered. If unclear answers were provided, and the interview did not advance, the interviewer asked to gain access to course literature or presentation material used in the lectures.

> What do you perceive to be the main challenges related to including sustainability content in education?

This question is purely related to the perceived challenges, highly subjective and dependent on the lecturer’s perspective. The question was asked and described further if the interviewee found the question confusing. Both a course perspective and a program perspective were included as some of the interviewees were engaged at both levels.

2.4.2 The Compilation and Analysis of Results

The results were recorded and placed into a mapping of each program. The results were then analyzed from several perspectives, including the overall prevalence of the different topics per program, the percentage covered of each of the topic-categories (as a function of the different tracks/specializations that students could choose) and the percentage of courses that would broach sustainability in some form (minimum and maximum scenarios were created per program). Together these give a holistic view of the sustainability education at each program.

The challenges identified by means of the second question during the phase 2 interviews were coded and then further compiled in a frequency distribution diagram. The results were then presented in form of an issue tree of the top ten perceived challenges. Three challenges (not amongst the top 3) were added in order to complete the diagram. These three challenges were not amongst the top 10 (having been explicitly mentioned less often) but were mentioned by interviewees that were deemed as knowledgeable about the programs and were in implicit agreement with the remaining interviews. There was overall agreement between the interviewees concerning the main challenges with integrating SC into education for industrial engineering students. The distribution further implies that the programs were subject to the same challenges to similar degrees.

3 Results and Analysis

The two phases, combined, resulted in five key insights, which will be presented in Fig. 1. The results will be covered in relation to each insight.

3.1 Broad Content List

The interview results were compiled into a content list for pedagogical purposes. The resulting division of the topics was into four main categories, one labeled as "general", one "environmental", one "social" and one "economic". The general category arose out of the interviews, from the interviewees mentioning different skills or bits of knowledge that were necessary for, or complemented, the more niched content within each aspect of sustainability. The insight that can be drawn from the content list is that the relevant topics span a broader range of fields than what is traditionally seen as engineering education (that is not to say that each need be covered in great depth). Amongst these fields you will find history, economics, law, sociology, ecology, psychology, management and more. Common for the interviews was that the problem definitions needed to be broader, taking more aspects into consideration, than simply technical or economic aspects. This is

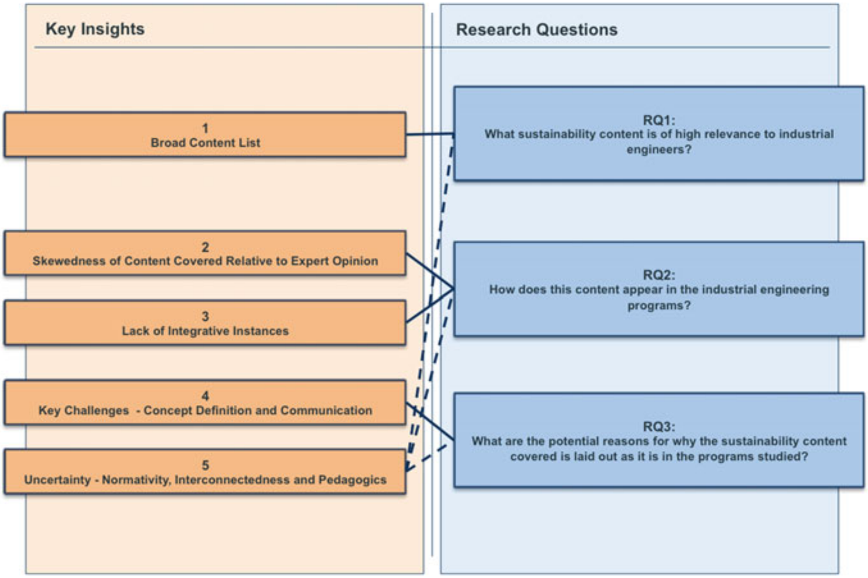


Fig. 1 The five key insights as tied to the research questions of the study

GENERAL		Code
The General Nature of the Sustainability Subject		G1
	Discussion of the conceptual division into aspects and their interconnectedness	G1.1
	Training in broader systemic view of sustainability	G1.2
	Training in interdisciplinary collaboration	G1.3
	Broaching the need for both qualitative and quantitative foci	G1.4
Emphasis and training in goal/vision based approaches		G2.0
Theory concerning how large societal change takes place		G3.0
Knowledge concerning societies goals and main impact contributors		G4.0

Fig. 2 Topics under the general category of the content list

consistent with the industrial engineer being intended as a bridge-builder between different disciplines (Universitetskanslerämbetet 2013) (Figs. 2, 3, 4 and 5).

The breadth of topics appears to have potential for developing the other 4 competencies as well, beyond the normative competency. The content list is meant to be interpreted as consisting of nested topics within each category (to show part of the internal structure within each category).

Environmental		Code
Discussing basic ecology on a local scale		M1
	Ecosystem services	M1.1
	Importance of biodiversity	M1.2
Discussing global environmental challenges		M2
	Climate change	M2.1
	Other global environmental challenges	M2.2
Discussing diminishing operating space		M3.0
Broaching strategies and tools to increase the environmental sustainability		M4.0

Fig. 3 The topics in the environmental category of the content list

Social		Code
Discuss social sustainability from a macro-perspective		S1
	The dynamics of social capital	S1.1
Discuss social sustainability from a micro-perspective		S2
	Self-Determination Theory	S2.1
	The importance of trust	S2.2
	Stress and security	S2.3
	Decision overload	S2.4
Broaching strategies and tools to increase the social sustainability		S3.0

Fig. 4 The topics in the social category of the content list

Economic		Code
Problematizing the economic aspect of sustainability		E1.0
Discussion on limiting and enabling institutional factors		E2
	The impact of norms and values	E2.1
	The impact of legislature	E2.2
	Questioning eternal economic growth	E2.3
	Short-termism	E2.4
	"The invisible hand"	E2.5
Discussing economic inequality		E3.0

Fig. 5 The topics in the economic category of the content list

3.2 Skewedness of Content Covered Relative to Expert Opinion

Below is the frequency distribution diagram of all studied courses (the mandatory and conditionally elective courses alike). The diagram displays the amount of times each program broached a certain topic. The topics are grouped (indicated by the coloured background) into the four categories mentioned earlier (see Fig. 6).

A clear preference for the environmental aspect is shown (particularly *M2.1*, *M2.2* and *M4.0*—global environmental challenges and tools for managing these challenges), with the economic and social aspects being broached sparingly. Other

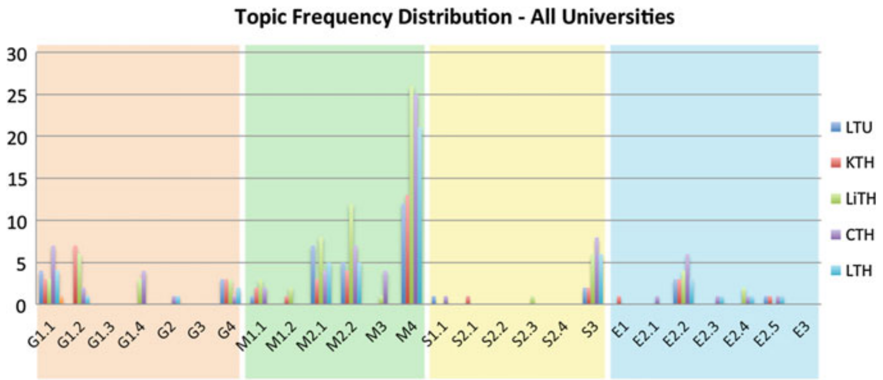


Fig. 6 The frequency of each topic per program. The colour and name of each topic displays the category to which it pertains

minor foci (topics which were broached relatively often at several programs e.g. *E2.2*) mainly revolve around definition of the subject and simpler topics that can be integrated easily into the current course curricula.

It is important to keep in mind that the data includes both mandatory and conditionally elective courses for all technical specializations and all master profiles. As such, the data cannot truly be said to be comparable between the programs, as different amounts of conditionally elective courses in the different programs will distort the results. The diagram does also not state how much SC each student receives in choosing a certain track. Rather, Fig. 6 mainly reveals what topics the programs are more comfortable with broaching. In this case, it primarily involves the environmental aspect. Topics such as the systems perspective (systems thinking comp.), social aspects and interdisciplinary collaboration (interpersonal comp.) and goal-based approaches (anticipatory and strategic comp.), to name a few, have potential to build the other key competencies, yet are seldom covered.

3.3 Lack of Integrative Instances

The normative competency, as described by Wiek et al., emphasizes the importance of mapping, specifying, applying, reconciling, and negotiating different values, principles, goals and targets (Wiek et al. 2011). One of the interviewees of the first phase also emphasized the interconnectedness of the subject's aspects and the importance of viewing them together as one subject, not as three clear-cut dimensions separate from each other (Finnveden 2015).

Figures 7, 8, 9, 10 and 11 display top and bottom scenarios of the coverage percentages of each category's topics (how many of the different topics of each category that each student encounters), taking the student's choice of specializations into consideration.

Based on the results shown in Figs. 6, 7, 8, 9, 10 and 11 we can see that the relevant content is not covered to a full extent. The normative competency, involving skills of applying, integrating and reconciling different principles, cannot be considered to be adequately developed through the current curriculum, as parts of the relevant content (primarily the social and economic aspects) are not being

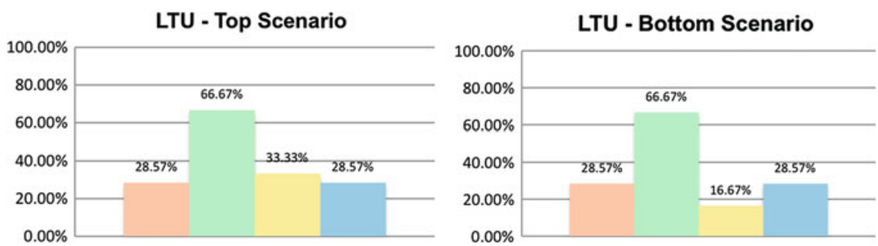


Fig. 7 Coverage percentages of each topic category for the program at LTU (Top and Bottom scenarios)

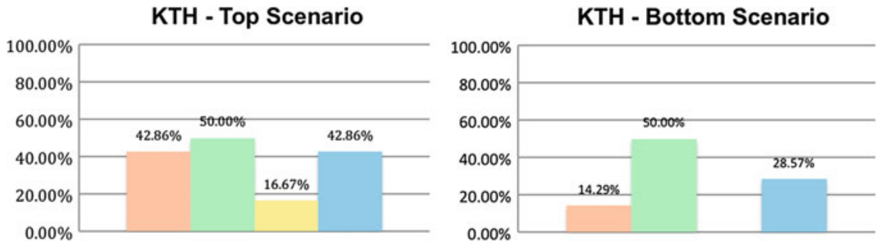


Fig. 8 Coverage percentages of each topic category for the program at KTH (Top and Bottom scenarios)

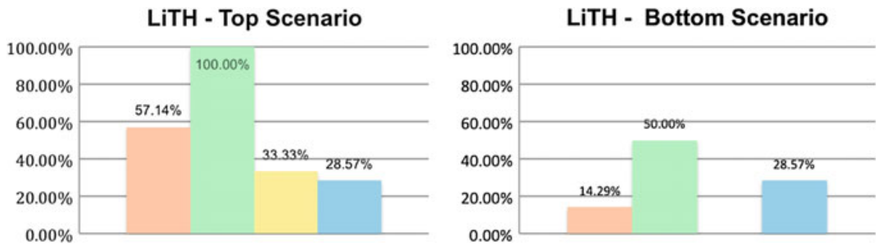


Fig. 9 Coverage percentages of each topic category for the program at LiTH (Top and Bottom scenarios)

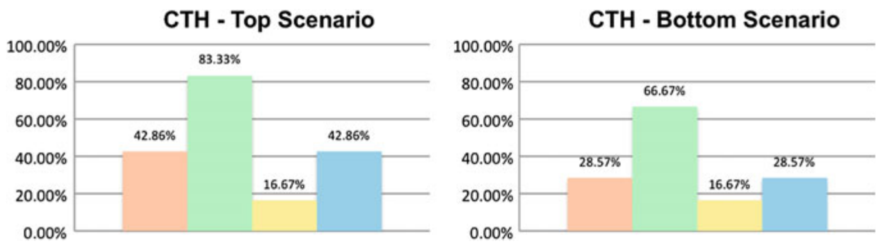


Fig. 10 Coverage percentages of each topic category for the program at CTH (Top and Bottom scenarios)

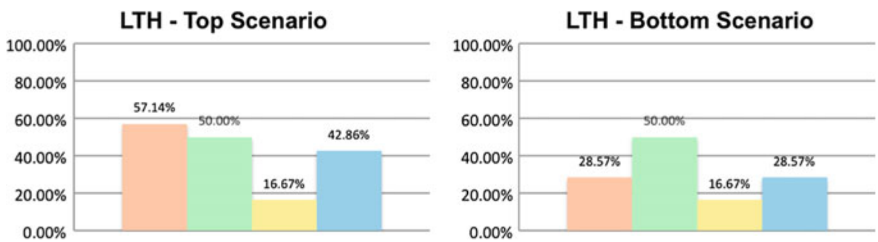


Fig. 11 Coverage percentages of each topic category for the program at LTH (Top and Bottom scenarios)

covered. Additionally, the mapping (not shown here) and large quantities of qualitative data suggest integrative instances, where different aspects are discussed collectively, to be rare.

The non-environmental aspects are generally not covered to the same extent, with *S3.0* and *E2.2* being the exceptions. This can be expected as the social aspect is the most abstract to define and manage, according to a study of one of the universities (Edvardsson-Björnberg et al. 2015) but generalizable for all, based on the interviews. The economic aspect, in turn, was often defined differently than what was recommended by the experts from phase 1.

3.4 Key Challenges

The key challenges in integrating this subject into programs and courses for industrial engineers were mapped with respect to the amount of times they were explicitly mentioned. Certain challenges would be mentioned together, or a dynamic would be mentioned that suggested implicit agreement on certain challenges. This qualitative data allowed for structuring of the challenges into an "issue tree" structure, displaying their interrelation. The top ten challenges were taken and organized into an issue tree and completed with three additional challenges, mentioned less frequently, but by trustworthy sources whose comments had implicit agreement with several others of the lecturers (see Fig. 12).

The connections illustrate the main causal relations. At the extremities of the tree, are the root challenges that give rise to the others and therefore illustrate the

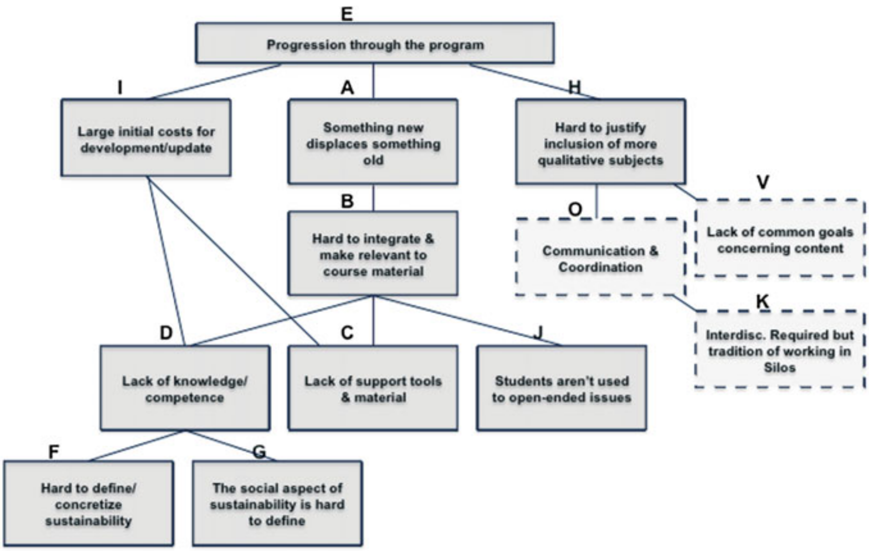


Fig. 12 Interrelation between main challenges

key points of leverage in order to facilitate an increase in SC at these programs. Many are endemic to the sustainability subject, or to academic endeavor in general (the branch starting with Challenge H). As such, it is likely that these challenges are representative for a larger population than just the programs studied.

The difficulties in implementation can be said to arise due to the lack of competence within the area and therefore the barriers to adopting this new content become larger. Furthermore, there is a lack of coordination and of a common vision for the sustainability education.

3.5 Uncertainty—Normativity, Interconnectedness and Pedagogics

The subject is normative, meaning there is always a component of subjectivity in the dialog. What is considered relevant, and what is considered enough SC is dependent on each observer's values and view of the industrial engineering role. This subjectivity denies objective judgment of quality and whether a particular course curriculum has a suitable amount of SC in it. The interconnectedness of the topics is another driver of uncertainty. This is true for the subject of sustainability itself (Finnveden 2015), for the competencies required to successfully integrate these issues in problem-solving (Wiek et al. 2011) and for judging whether a course covered one topic or another. This uncertainty is however seen as low for this study as effective measures were taken to reduce it. Lastly, the pedagogics of the lecturer affects what is understood by the students. The student perspective was not part of this study and is an interesting topic for future studies, which could lend further insight into how the current SC is perceived and how to effectively implement SC in the future. The current approach is partial to the faculty perspective. Including student perceptions could give a more complete picture.

The factors of uncertainty had limited impact on the viability of the quantitative results achieved. The main impact of the uncertainty was seen in the impossibility of drawing conclusions related to quality of the teaching.

4 Conclusions

The identified relevant content spans a broad range of disciplines (*1*), there is a skewedness in the content covered at the studied programs (*2*), there is a lack of integrative instances in these programs (*3*), the main challenges generally pertain to knowledge of the subject and communication within the faculty (*4*), normativity, interconnectedness, and pedagogy make it impossible to objectively judge quality (*5*). These five key insights lead one to conclude that the current sustainability education does not fulfill the criteria for developing the necessary competencies concretized by Wiek et al. The broad content that is relevant and the lack of coverage (particularly of certain areas) indicate that the competences are not being developed to the necessary degree. The lack of integrative instances indicate the normative competence is not being developed sufficiently, potentially limiting the development of the other competencies. Whether this means that the level of SC in these programs is adequate or not, depends on the normative standpoint of the reader.

Finally, a short mention of the key success factors to the method, as identified by the author. For the first phase, the reputability of the interviewees was seen as important to ensure the quality of the whole study and enabling the second step. In the second phase, the good intention and non-threatening language was deemed vital in allowing good rapport and honest answers to prevail. Through these factors, both legitimacy and reliability was achieved.

Acknowledgments This study was made possible by the warm contributions of over a 100 people from five programs, ten universities and countless departments from all over Sweden. A big thank you to all of you.

References

Antagning.se. (2015). Universitets- och Högskolerådets antagningsstatistik (*University and College admission statistics*). Antagning.se, http://statistik.uhr.se. Last accessed October 19, 2015.

Becker, E., Jahn, T., & Stiess, I. (1999). *Sustainability and the social sciences, a cross-disciplinary approach integrating environmental considerations into theoretical orientation*. London, United Kingdom: Zed Books.

Byrne, E. (2012). Teaching engineering ethics with sustainability as context. *International Journal of Sustainability in Higher Education, 13*(3), 232–248.

Carew, A., & Mitchell, C. (2007). Teaching Sustainability as a contested concept: Capitalizing on variation in engineering educators' conceptions of environmental, social and economic sustainability. *Journal of Cleaner Production, 16*, 105–115.

Chalmers Technical University. (2010). *Alumni 2010—Industriell Ekonomi. Technology's economy and organisation*. Gothenburg: Chalmers.

Collis, J., & Hussey, R. (2009). *Business research* (3rd ed.). Houndmills, Hampshire, UK: Palgrave Macmillan.

Dahlin, J.-E. (2014). Hållbar Utveckling (*Sustainable Development*). Lund Studentlitteratur.

de Vries, B., & Petersen, A. (2009). Conceptualizing sustainable development: An assessment methodology connecting values, knowledge, worldviews and scenarios. *Ecological Economics, 68*, 1006–1019.

Edvardsson-Björnberg, K., Skogh, I.-B., & Strömberg, E. (2015). Integrating social sustainability in engineering education at the KTH Royal Institute of Technology. *International Journal of Sustainability in Higher Education, 16*(5), 639–649.

Finnveden, G. (2015). *Vice-president of sustainability*. Stockholm: Royal Institute of Technology (KTH). Interviewed by Niccolas Albiz on the Match 27, 2015.

Fisher, R. (1993). Social desirability bias and the validity of indirect questioning. *Journal of Consumer Research, 20*, 303–315.

Hanning, A., Abelsson, A., Lundqvist, U., & Svanström, M. (2010). Are we educating engineers for sustainability? *International Journal of Sustainability in Higher Education, 13*(3), 305–320.

Henningsson, M. (2015). *Chairman of the board of industrial engineering and logistics*. Linköping: Linköping University. Interviewed by Niccolas Albiz on the April 15, 2015.

I-sektionens Alumnutskott. (2013). Alumnrapport 2013 (*Alumni report 2013*). Lund: Lund's Technical University, Association of Industrial Engineers.

I-sektionens Alumnutskott. (2011). Placement Report 2011—en rapport om Iares första anställning (*Placement Report 2011—A report about I-students first employment*). Linköping's University, Association of Industrial Engineers, Linköping.

I-Sektionens Alumnutskott. (2012). *Placement report 2012*. Linköping: Linköping's University, Association of Industrial Engineers.

Jacobsen, D. (2002). Vad, hur och varför: om metodval i företagsekonomi och andra samhällsvetenskapliga ämnen (*What, how and why: About method choices in business and other social science subjects*). Lund: Lund Studentlitteratur.

KTH-Sustainability. (2014). Precisering av övergripande lärandemål (*Specification of the overarching learning outcomes*). KTH-Sustainability. https://www.kth.se/om/miljo-hallbar-utveckling/utbildning-miljo-hallbarutveckling/verktygslada/larande-for-hallbar/outcomes/precisering-av-overgripandelarandemal-1.432077. Last accessed October 21, 2015.

Lang, D., Wiek, A., Bergmann, M., Moll, P., Swilling, M., Stauffacher, M., et al. (2012). Transdisciplinary research in Sustainability Science: Practice, principles and challenges. *Sustainability Science, 7*(1), 25–43.

Lee, R. (1993). *Doing research on sensitive topics*. London, England: Sage Publications.

Littig, B., & Griessler, E. (2005). Social Sustainability: A catchword between political pragmatism and social theory. *International Journal of Sustainable Development, 8*(1), 65–79.

Mulder, K. (2010). Dont Preach. Practice! Value laden statements in academic sustainability education. *International Journal of Sustainability in Higher Education, 10*(1), 74–85.

Nederhof, A. (1985). Methods of coping with social desirability bias: A review. *European Journal of Social Psychology, 15*(3), 263–280.

Royal Institute of Technology (KTH). (2007). Karriärrapport 2007 (*Career report 2007*). Royal Institute of Technology (KTH). https://intra.kth.se/polopoly_fs/1.172250!/Menu/general/column-content/attachment/Karriärrapport%202007.pdf. Last accessed May 06, 2015.

Royal Institute of Technology (KTH). (2010). Karriärrapport 2010 (*Career report 2010*). Royal Institute of Technology (KTH). https://www.kth.se/polopoly_fs/1.272875!/Menu/general/column-content/attachment/Karriärrapport%202010%20(2).pdf. Last accessed May 06, 2015.

Royal Institute of Technology (KTH). (2011). Karriärrapport 2011 (*Career report 2011*). Royal Institute of Technology (KTH). https://www.kth.se/polopoly_fs/1.276786!/Menu/general/column-content/attachment/Karriärrapport%202011.pdf. Last accessed May 06, 2015.

Strömberg, E. (2015). *Project manager at KTH-Sustainability*. Stockholm: Royal Institute of Technology (KTH). Interviewed by Niccolas Albiz on the March 05, 2015.

UN Global Compact & Accenture. (2013). UN global compact—Accenture CEO study on Sustainability 2013. Accenture Sustainability Services. Accenture. https://acnprod.accenture.com/~/media/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Strategy_5/Accenture-UN-Global-Compact-Acn-CEO-Study-Sustainability-2013.pdf. Last accessed August 21, 2015.

Universitetskanslerämbetet. (2013). Utvärdering av utbildningar inom ingenjörs- och teknikvetenskap 2013—Arbetssätt, resultat, analys och reflektioner (*Evaluation of educations within engineering and technology sciences 2013—Methods, Results, Analysis and reflections*). http://www2.uk-ambetet.se/download/kvalitet/industriell-ekonomi-2012.pdf. Last accessed August 21, 2015.

Wals, A., Tassone, V., Hampson, G., Reams, J. (2015). Chapter 2—Learning for walking the change. In *Routledge Handbooks of Higher Education for Sustainable Development* (pp. 25–39).

Wiek, A., Withycombe, L., & Redman, C. (2011). Key competencies in sustainability: A reference framework for academic program development. *Sustainability Science, 6*, 203–218.

Author Biography

Mr. Niccolas Albiz has a masters of science in engineering from the Industrial Engineering and Management program at the Royal Institute of Technology, KTH. After graduation he started working at the Industrial Engineering and Management program to support the program, and its equivalents all over Sweden, in integrating sustainability into the education.

Implementing Sustainability in the Classroom at Université Laval

Vincent Richard, Daniel Forget and Noémie Gonzalez-Bautista

Abstract

Université Laval has embraced a global approach to sustainability education. Although sustainability has been addressed in the classroom by individuals in the past, it is now being articulated with a vision. In May 2009, the *Study Council* voted to add a new article to the university's *Academic Regulations* stating that all undergraduate students must be introduced to the concept of sustainability. This decision was followed by the creation, in 2012, of a multi-cycle, interfaculty committee on sustainability education. In order to obtain and maintain sustainability certifications, Université Laval must submit lists of courses and programs related to sustainable development. This obligation presented an opportunity to develop a unique and global approach in collaboration with professors and heads of programs. Based on Wiek and collaborators' report entitled "*Key competencies in sustainability: a reference framework for academic program development*" (2011), a mandated work group produced a survey on courses and programs. This survey was created to gain a better understanding of the scope of sustainability education at Université Laval and how sustainability competencies can be developed in any field of studies. This case study is an illustration of concrete and transparent measures that could be implemented in order to make account of SD training on offer.

V. Richard (✉) · D. Forget · N. Gonzalez-Bautista
Université Laval, Québec, QC G1V 0A6, Canada
e-mail: Vincent.Richard@fse.ulaval.ca

D. Forget
e-mail: Daniel.forget@dgpc.ulaval.ca

N. Gonzalez-Bautista
e-mail: noemie.gonzalez.1@ulaval.ca

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_9

Keywords
Sustainability · Implementation · Universities

1 Introduction

As a sizable institution of higher learning, Université Laval first began to offer courses in sustainable development (SD) through the various initiatives of professors concerned with keeping their courses up-to-date and with the social and professional developments taking place in their fields of study. SD thus emerged in university education in the same way that it emerged, several decades ago, as a concern in contemporary society. The diversity of approaches, perspectives, and educational objectives specific to the various disciplines or professions, associated with the different undergraduate programs at Université Laval, made the task of identifying courses and programs in SD particularly difficult and complex. Not surprisingly, the actors attempting to do so also recognized the magnitude of this task.

This article presents the original and solid theoretical approach implemented by the *Comité-conseil sur l'offre de formation en développement durable* (CCOFDD, advisory committee on sustainability education) at Université Laval between Fall 2012 and late Spring 2014. Based on a case study, we will show that the procedures put in place allowed the committee to fulfill its mandate, and, especially, provided a framework of reference enabling all the actors involved in this process to adopt a common language for the purpose of identifying courses and programs in SD on offer at Université Laval.

1.1 SD at Université Laval

As expressed by the senior administration, SD is a priority for Université Laval. The many sustainability initiatives found on campus, impacting the living environment and promoting healthy lifestyle habits, bear witness to the university's desire to improve the quality of life for the university community. While encouraging individuals to adopt values in line with SD, the university is also anxious to ensure that its own choices are consistent with sustainability principles. As stated by the Rector and Vice Rector, "Sustainable development is at the very heart of Université Laval's *raison d'être*, that is, to acquire and transfer knowledge. The quality of its commitment regarding sustainable development has earned an international recognition, with the prestigious distinction of a STARS (Sustainability Tracking Assessment and Rating System) Gold rating awarded by the Association for the Advancement of Sustainability in Higher Education in 2014. Of some 300 participating institutions, Université Laval ranked first among universities in

Canada and ninth among those in the world" (Université Laval 2015, trans.). Not surprisingly then, a considerable effort has been made to identify SD courses and programs on offer at Université Laval.

2 Drawing up a List of Courses in SD

2.1 The Mandate and Task of the Advisory Committee

In 2012, Bernard Garnier, Vice Rector, Academic and International Activities, and Éric Bauce, Executive Vice Rector, Development, set up an advisory committee on sustainability education (the CCOFDD) with the mandate to promote academic programs in SD at the undergraduate, Master's and doctorate levels. The CCOFDD was also given the mandate to develop the criteria used to determine which courses and programs would qualify as courses and programs in SD. To this end, the CCOFDD set up an ad hoc committee tasked, among other things, with establishing the criteria to be used to identify courses and programs in SD and a procedure for labelling the courses that meet these criteria.[1]

2.2 A List of Courses in SD

Drawing up a representative list of courses in SD raises several challenges in itself. Indeed, the committee quickly realized that the curricular focus of the different disciplines corresponding to the vast majority of undergraduate programs often involves very specific objectives, but also, and especially, a very particular view of the issues and challenges relating to SD. Given these multiple definitions of and perspectives on SD, the committee soon realized that a knowledge-based approach was untenable since it would be impossible to come up with an exhaustive summary of the knowledge acquired in such a vastly diverse set of courses.

The CCOFDD's ad hoc committee thus conducted a literature review to explore the various types of courses and programs on offer in the area of SD. This led them to Wiek et al.'s (2011) systematic literature review identifying common and recurring elements associated with sustainability-related courses and programs in higher education. This systematic literature review suggested that most approaches to sustainability education focus on the capacity to solve problems in complex situations (historical context, multiple actors, various perspectives, etc.) and a concern for the future repercussions of decisions.

As pointed out by Wiek et al., "Frameworks or unifying themes for key competencies in sustainability are not frequently used or discussed in the literature. 'Laundry lists' without transparent selection criteria dominate the discourse. It

[1]The committee also worked to establish the criteria for evaluating programs, but this work is not presented here.

seems that the field is still in search of over-arching concepts that would relate and integrate sustainability competencies in a meaningful way. The few frameworks proposed, applied, or discussed are inspired by transformative learning concepts and propose [some specific] key competencies" (Wiek et al. 2011, p. 205). This finding was in line with the view of the ad hoc committee. Wiek et al. suggest that, in a very general way, five key competencies in SD form a sort of common structure underlying the various approaches identified. This review convinced the committee that a competency-based approach would be best suited to the process of establishing the criteria to be used to identify courses and programs in SD. A competency-based approach offers many advantages. Essentially, it is student-centered, focusing on the resources that students need to integrate and mobilize in order to carry out tasks or actions in any new situation (Maingain et al. 2002). In general terms, competencies in SD can thus be summed up as the mobilization of a combination of knowledge, skills, and attitudes that make successful task performance possible and enable problem solving with respect to real-world sustainability problems, challenges, and opportunities (c.f. Barth et al. 2007; Dale and Newman 2005; Rowe 2007).

2.3 Theoretical Approach

One of the structuring elements of Wiek et al.'s work (2011) is the integrated framework they propose, linking the various stages involved in solving complex sustainability problems. Conceptualizing their approach to sustainability education in terms of complex problem solving, Wiek et al. (2011) thus situated the various competencies that a sustainability-related program should enable students to develop. They thus proposed five key competencies encompassing the main educational objectives related to SD. According to the ad hoc committee, these competencies can be presented as follows:

- **Systems-thinking competence**: The ability to analyze real, complex problems in a comprehensive manner and in context (requires an interdisciplinary approach);
- **Anticipatory competence**: The ability to evaluate the potential consequences of human intervention or non-intervention;
- **Normative competence**: The ability to explicitly include the normative factors that help guide decision-making (values, rules, consequences, goals, etc.);
- **Strategic competence**: The ability to come up with inclusive and applicable solutions to complex problems;
- **Interpersonal competence**: The ability to create opportunities for dialogue, debate and discussion (with a view to collaborative problem solving).

Based on their review of the literature on key sustainability competencies, Wiek et al. concluded that these five competencies must be built in conjunction with the "basic" professional competencies needed for any problem solving. They also recognized that "interpersonal" competence stands apart from the other four key competencies in SD. Indeed, all five competencies clearly contribute to the problem-solving process. However, it can also be said that the first four competencies refer to immediate problem-solving processes whereas interpersonal competence refers more to the ability to create an environment in which collaborative problem solving is possible. It is not a question here of prioritizing these competencies, but rather of gaining a better understanding of the very possibility of recognizing their development in the context of a university education.

This theoretical approach, based on an extensive literature review, was adopted by the CCOFDD to guide the task of identifying courses and programs in SD at Université Laval. In the CCOFDD's view, this approach allows for the development of a common language, a sort of standard to be used to identify the various ways of integrating SD into an academic program. It also ensures a degree of transparency in the process of identifying and labelling these courses and programs.

2.4 Operationalizing the Process of Drawing up a List of Courses in SD

The theoretical approach adopted by the ad hoc committee allowed the CCOFDD to begin the process of identifying courses in SD on offer at Université Laval. To operationalize this process, the committee decided to make explicit several premises underlying the choices it had made.

One of the principles guiding the ad hoc committee's work was its view that the professor in charge of a course is best qualified to analyze the latter and determine whether or not it constitutes a course in SD. This principle recognizes the expertise of the professors concerned, but puts them in the delicate position of having to evaluate, in a way, the content of their courses. For the committee, this principle implied the need to develop a tool that professors could use to examine their courses. Thus, given the mandate to draw up a list of courses addressing SD at Université Laval, considering the above principle, and recognizing that courses can evolve over time as the university faculty renews itself, the CCOFDD decided to develop a questionnaire to guide professors through the process of analyzing the course outlines of their courses and deciding whether or not the latter contribute to sustainability education at Université Laval. Moreover, given that the course outline explicitly sets out the course content and, in turn, determines students' expectations regarding the course, the CCOFDD considered that the course outline provides the best indication of a course's educational objectives.

The CCOFDD is aware that this way of proceeding opens the door to possible problems regarding a course's qualification as an SD course. However, disregarding the following two premises—namely, (1) that the professor is in the best position to analyze the content of his/her own course, and (2) that the course outline best indicates the educational objectives of a course—would also open the door to problems that could make the analysis irrelevant or inadequate.[2]

3 Survey of SD Courses

3.1 Methodology

In terms of method, this research adopts a case study approach. The questionnaire was sent, June 2014, to all professors at Université Laval (n > 1500). Data thus collected would give a first portrait of the scope of sustainability education of offer at Université Laval.

3.2 Developing the Questionnaire

The ad hoc committee thus produced a questionnaire that would enable the professors in charge of courses to analyze the course outlines of their various courses and determine whether the latter contributed in one way or another to the development of the key competencies in SD. In line with Wiek et al. (2011), the CCOFDD concluded that it would be relevant to exclude from this questionnaire any items related to the development of "interpersonal competence." The reasons behind this decision were relatively straightforward: it is usually considered that the development of interpersonal competence will be taken care of at the program level[3] rather than at the level of individual courses. Moreover, since the vast majority of undergraduate courses are geared towards the educational objectives of specific disciplines, anything related to the development of interpersonal competence, as understood by Wiek et al. (2011), appears a priori to be covered by the disciplinary curricula. Furthermore, article 104 of Université Laval's Academic Regulations[4] specifies the need, in any undergraduate program, to develop cross-cutting competencies that correspond, in part, to the various components of Wiek et al.'s (2011) interpersonal competence.

Before answering the questionnaire items, the professor can access several documents explaining different aspects of the approach. Thus, in addition to providing spaces to identify the course in question and the professor in charge, the first part of the questionnaire includes three hyperlinks to information on the three

[2]Before presenting the approach used, it can be said that a high number (approximately 45 %) of the analyses conducted by the professors in charge of courses led them, based on their answers to the questionnaire, to conclude that their courses did not qualify as SD courses.

[3]This competence will thus be found in the analysis of programs currently underway.

[4]Online (in French only): https://www2.ulaval.ca/fileadmin/Secretaire_general/Reglements/reglement-des-etudes-03062014.pdf.

> **IDENTIFICATION**
>
> Duration of the questionnaire: 15 minutes
>
> This questionnaire aims to determine whether the course in question is consistent with a particular approach to sustainability education. The conception of sustainable development (SD) retained here is based on the vision of SD that Université Laval ascribes to, as well as on the 16 principles set out in Quebec's Sustainable Development Act.
>
> 1. Course identification code or name.
>
> 2. Institutional email address of the professor in charge of this course.
>
> For additional information, please click on the hyperlinks contained in the questionnaire. You can also download a brochure summarizing all this information by clicking here.
>
> Please note that it will not be possible to save the questionnaire as you go along.
>
> To help you fill out this questionnaire, we suggest that you to refer to your course outline. Don't forget to click on "Send" when the questionnaire has been completed.

Fig. 1 Part 1 of the questionnaire: identification

conceptual underpinnings[5]: Wiek et al.'s (2011) approach to sustainability education, the vision of SD that Université Laval ascribes to, and the 16 principles set out in Quebec's SD Act (Fig. 1).[6]

The CCOFDD set out to produce a user-friendly questionnaire that would not take long to complete (15 min) so as to encourage as many professors as possible to fill it out. The CCOFDD thus decided to ask a very limited number of questions and to keep the questions short. The questionnaire items are rated on a Likert scale, indicating the extent to which the respondent agrees or disagrees with the statement expressed in each question. The use of this scale simplifies the processing of the professor's assessment.

3.3 The Questionnaire Items

The main body of the questionnaire is divided into four parts, each presenting one key competency. Each key competency is assessed through a limited number of items, covering its various facets. Several hyperlinks are provided along the way, leading to documents explaining some of the terms used. The number of items used to assess each key competency corresponds to the number of components of the competency as set out in Wiek et al. (2011). It in no way conveys a prioritization among the competencies.

[5]Note: it is also possible for the professor to download a brochure that presents the questionnaire in detail and includes all the information found in the various hyperlinks provided.

[6]Online: http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=2&file=/D_8_1_1/D8_1_1_A.html.

3.3.1 Systems-Thinking Competence

The first key competency assessed in the questionnaire is referred to as systems-thinking competence (Fig. 2). The professor is asked whether one of the aims of the course is to develop the capacity to analyze complex problems in a comprehensive manner, in context, across different disciplines and different scales. Developing this competence leads students to consider the interactions between the structures and systems in society, including values, cultures, conceptions, preferences, needs, institutions and actors. A course that develops systems-thinking competence promotes:

- A deepening of knowledge related to a specific discipline;
- The exploration and mastery of various models, paradigms and points of view;
- Openness to change and difference;
- Recognition of the contribution made by other disciplines when it comes to identifying the issues (interdisciplinary approach);
- A long-term outlook.

3.3.2 Anticipatory Competence

This key competency corresponds to the capacity to evaluate the consequences of human intervention or non-intervention in future scenarios, based on various qualitative or quantitative data (Fig. 3). By developing this competence, students are enabled to address and reflect on various challenges related to SD based on different scenarios involving intervention or non-intervention by humans within a specific timeframe, that is, (a) on a past-present-future continuum, and (b) over the short, medium or long-term.

Developing this competence also entails mastering tools that can be used to project into the future, such as statistical models, simulated scenarios, etc. A course that contributes to the development of anticipatory competence thus focuses on:

- Developing multi-dimensional, creative and innovative ideas or solutions;
- Assessing the relevance of ideas or solutions;
- Considering the principle of prevention and the precautionary principle;
- Prioritizing solutions that respect intergenerational equity;
- Envisioning desirable scenarios for a sustainable future.

3.3.3 Normative Competence

The third key competency assessed by the questionnaire relates to the normative aspects of complex problems (Fig. 4). This competency is demonstrated by the capacity to explicitly include the various normative factors that help guide decision-making in the analyses and discussion. This includes legal and ethical aspects, such as values, rules, consequences, laws, etc. In short, the development of

SYSTEMS-THINKING COMPETENCE
To what extent does this course aim to enable students to:
3. Analyze the structures, dynamics or issues underlying the challenges of SD?
- Entirely
- To a large extent
- A little
- Not at all

4. Problematize complex situations related to the challenges of SD?
- Entirely
- To a large extent
- A little
- Not at all

5. Analyze the interactions between various perspectives (points of view, scales or disciplines) regarding the challenges of SD?
- Entirely
- To a large extent
- A little
- Not at all

Fig. 2 Items used to assess "systems-thinking competence"

ANTICIPATORY COMPETENCE
To what extent does this course aim to enable students to:
6. Analyze the possible consequences of human action and consider the concept of responsibility, within an SD perspective?
- Entirely
- To a large extent
- A little
- Not at all

7. Consider the principle of prevention and the precautionary principle within an SD perspective?
- Entirely
- To a large extent
- A little
- Not at all

8. Consider the concept of intergenerational equity within an SD perspective?
- Entirely
- To a large extent
- A little
- Not at all

9. Devise and analyze various scenarios within an SD perspective?
- Entirely
- To a large extent
- A little
- Not at all

Fig. 3 Items used to assess "anticipatory competence"

this competence enables students to identify and adapt proposed solutions to problems in accordance with the values, rules and other norms inherent in the systems in place, mobilizing the concepts of justice, equity and systems integrity to solve problems within a perspective of SD.

A course that contributes to the development of normative competence promotes:

NORMATIVE COMPETENCE
To what extent does this course aim to enable students to:
10. Analyze the legal or ethical aspects of the challenges of SD?
- Entirely
- To a large extent
- A little
- Not at all

11. Address the diverse values or principles underlying the challenges of SD?
- Entirely
- To a large extent
- A little
- Not at all

Fig. 4 Items used to assess "normative competence"

- A human-centred focus with an emphasis on human rights and social obligations;
- Analysis that takes into account the principles of social and environmental justice and intergenerational equity;
- A focus on bringing out the values at stake;
- The notion of personal and collective responsibility.

3.3.4 Strategic Competence

The last key competency assessed by the questionnaire is strategic competence (Fig. 5). This competence is related to the methodological aspects of any problem solving process from an SD point of view. It refers to the ability to propose inclusive and applicable solutions to complex problems, an essential skill for effective problem solving. It involves using various types of analysis (e.g. qualitative, quantitative or contextual analysis) and the capacity to compare and critically assess different points of view on a subject in order to come up with solutions that are viable in different disciplines, with a view to collective problem-solving in complex situations. Moreover, the capacity to implement an intervention strategy in response to a complex problem is contingent on the ability to organize and mobilize resources such as knowledge, techniques, and analytical and assessment tools, as well as different stakeholders. Ultimately, it is a question of helping students develop the capacity to propose innovative solutions, think outside the box and overcome constraints so as to reframe solutions more effectively.

A course that develops this competence focuses on building:

- Project management skills;
- The facility to develop innovative solutions, open up new avenues and implement new ways of doing things;

STRATEGIC COMPETENCE
To what extent does this course aim to enable students to:
12. Develop the capacity to solve complex problems underlying the challenges of SD?
- Entirely
- To a large extent
- A little
- Not at all

13. Develop the capacity to analyze administrative, political and governance-related constraints in order to guide interventions within an SD perspective?
- Entirely
- To a large extent
- A little
- Not at all

14. Develop and implement policies, action plans, programs or management systems within an SD perspective?
- Entirely
- To a large extent
- A little
- Not at all

Fig. 5 Items used to assess “Strategic competence”

- The ability to identify the main levers, key actors, and significant partners that will support the process of organizational transformation;
- The capacity to put in place policies and action plans to support and guide various methods of problem-solving);
- The ability to identify performance indicators for measuring change (accountability).

3.3.5 Overall Analysis of the Course by the Professor in Charge

The last section of the questionnaire provides ample space for comments (Fig. 6). It allows the professors to bring out some elements of the course that may not have been covered by the questionnaire and which, in their opinion, contribute to sustainability education. This section also allows respondents to express their opinions on both the content of the questionnaire and the entire process itself. It represents a way for the ad hoc committee to obtain feedback on this process.

Lastly, the professor is asked to say how the course contributes to sustainability education (Fig. 7). Four choices are provided: either the course does not address

CONCLUSION

15. Does this course address any elements pertaining to sustainable development that are not set out explicitly in the course outline? If so, in what way?

Does this course address any other aspects of sustainable development? If so, which one(s)?

Do you have any other comments?

Fig. 6 Conclusion of the questionnaire

16. Considering all your answers to the questionnaire, would you say that this course is:
- o An awareness-raising course in SD
- o An introductory course in SD
- o An in-depth course in SD
- o None of the above

Cancel **Send**

Fig. 7 The course's contribution to sustainability education at Université Laval

SD, or it represents an awareness-raising course, an introductory course or an in-depth course in SD. Considering the latter three levels of SD integration makes the process of identifying the diverse courses in SD on offer at Université Laval more inclusive and explicit.

Hence, this questionnaire was developed by the CCOFDD as a tool to document, based on a solid theoretical approach, the courses in SD on offer at Université Laval, in accordance with the committee's mandate.

3.4 Preliminary Results of the First Version of the Questionnaire

Once the questionnaire was developed, the CCOFDD's ad hoc committee put in place procedures to enable professors to fill out the questionnaire for any course they were in charge of. To this end, a hyperlink leading to the questionnaire was sent to all professors in charge of courses at Université Laval. The questionnaire was distributed in three waves, between 2013 and 2015 (reaching approximately 1500 professors). As of September 1, 2015, 607 courses had been analyzed by these professors. Of these 607 courses, approximately 336 were duly identified by this process as constituting courses in SD. The data collected enabled the CCOFDD to make several observations regarding the course offering in SD at Université Laval. In particular, the CCOFDD noted that the distribution between the different types of courses in SD (awareness-raising, introductory, in-depth courses) was fairly well balanced, which, in the CCOFDD's view, validates the relevance of this classification system. More specifically, 145 awareness-raising courses, 73 introductory courses and 118 in-depth courses in SD were identified. The CCOFDD also noted a relatively equal distribution between undergraduate level courses and Master's level courses. Thus, approximately 65 % of the courses in SD identified were at the undergraduate level while approximately 35 % were at the Master's level. Moreover, courses in SD were identified in over 50 disciplines or fields of study. For the purpose of clarity, all of these courses are labelled as "SD" courses in the various educational programs.

An analysis of the questionnaire also brought out the extent to which each key SD competency was addressed by the courses analyzed. A quick look at Fig. 8 shows that "systems-thinking competence" and "anticipatory competence" were

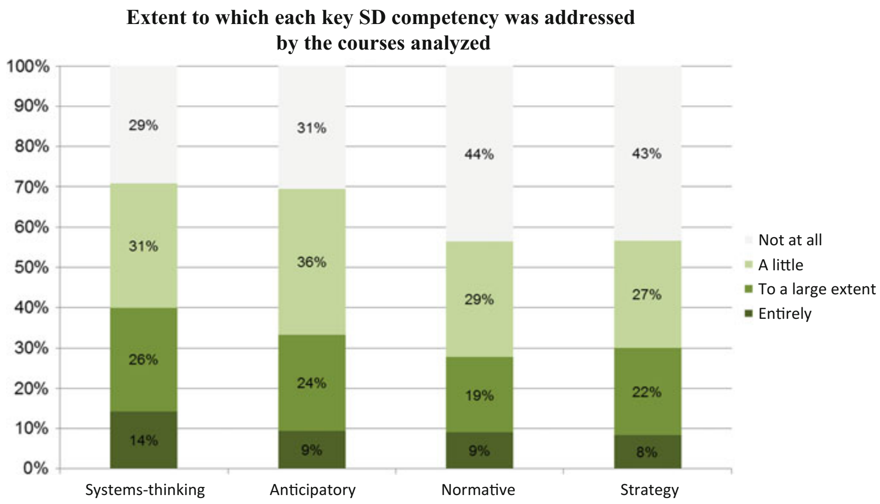


Fig. 8 Extent to which each key SD competency was addressed

deemed to be addressed to a slightly greater extent than "normative competence" and "strategic competence."

Furthermore, over 200 comments were collected, many of which expressed a desire, on the part of the professors, to rework their course outlines, or even the courses themselves, in order to more explicitly include educational components related to the key SD competencies. In the CCOFDD's view, these comments testify to the extent of the professors' commitment, but also the educational nature of the process itself.

3.5 Challenges and Difficulties

The CCOFDD found this process to be highly successful. However, there remains room for improvement. First, one of the limitations of the closed question approach is the difficulty of considering project-based courses, internships, integrative courses, etc., the nature of which can depend on the choices made by students or even, for example, the educational objectives of a professional program. Also, the ad hoc committee is still considering the relevance of re-introducing interpersonal competence in order to be more consistent with the theoretical framework on which this process is based. Moreover, it should be noted that this process is largely based on the professor's subjective evaluation. Lastly, no mechanism for validating the questionnaire had yet been devised.

4 Conclusion

In September 2015, following three years of work, a list of courses in SD on offer at Université Laval began to emerge. The process put in place was intended to be consistent with the vision of SD ascribed to by Université Laval, that is, an operational and transparent process that was as objective and professional as possible. Despite, or perhaps because of, its great simplicity, the questionnaire developed by the ad hoc committee proved to be a very operational tool. Moreover, the numerous and very constructive comments made by the professors showed the extent to which this tool encouraged the latter to introduce key SD competencies in the classroom.

Work remains to be done and numerous challenges lie ahead. The questionnaire needs to evolve. There is a room to innovate further and to document the educational initiatives that are continually being developed on campus. Now that the process of identifying courses in SD is well underway, the CCOFDD is turning its focus to the identification of programs in SD. This second phase of the process will be based directly on the findings that emerged from the first phase. More than merely producing a list of courses in sustainability, we believe that the committee's approach has led to a better understanding of the scope of sustainability education on offer at Université Laval and helped facilitate its implementation in the classroom.

Acknwoledgment The authors would like to thank the members of the advisory Committee on sustainability education (CCOFDD) for their contribution to this paper.

References

Barth, M., Godemann, J., Rieckman, M., & Stoltenberg, U. (2007). Developing key competencies for sustainable development in higher education. *International Journal of Sustainability in Higher Education, 8*, 416–430.

Dale, A., & Newman, L. (2005). Sustainable development, education and literacy. *International Journal of Sustainability in Higher Education, 6*(4), 351–362. doi:10.1108/14676370510623847

Maingain, A., Dufour, B., & Fourez, G. (2002). *Approches didactiques de l'interdisciplinarité*. Bruxelles: DeBoeck Université.

Rowe, D. (2007). Sustainability: Education for a sustainable future. *Science, 317*, 323–324.

Université Laval. (2015). 2015–2018 plan to fight climate change: Achieving and maintaining carbon neutrality. Online: http://www2.ulaval.ca/fileadmin/developpement_durable/documents/Carboneutralite/plan-to-fight-climate-change-Universite-Laval-2015-2018.pdf

Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: A reference framework for academic program development. *Sustainability Science*, *6*(2), 203–218. doi:10.1007/s11625-011-0132-6

Authors Biography

Professor Vincent Richard is graduated in Philosophy (2002), holds a master degree in Applied Ethics (2004) and a Ph.D. in Science Education (2012). He is currently Assistant Professor at Université Laval, Québec (Canada), working in the Teacher Education Program—Primary education. His research interests include the study of the relationships between sciences and society and its integration into the formal curriculum in science education.

Daniel Forget worked for 4 years in characterization and rehabilitation of contaminated sites as a graduate in geological engineering of the École Polytechnique de Montréal. He holds a graduate degree in eco consulting (Université du Québec à Chicoutimi) and was employed as an eco-advisor at Cégep de Victoriaville for more than 3 years. Mr. Forget is now an operations coordinator for undergraduate study direction at Université Laval, where he works to integrate concepts of sustainable development at the heart of university undergraduate programs.

Noémie Gonzalez Bautista is graduated in biology (2004). She holds a Master's degree in environmental science (2005) and a Master's degree in environmental anthropology (2011) from the Museum national d'Histoire naturelle of Paris. Currently PhD candidate at Université Laval, Québec (Canada), she navigates on an interdisciplinary path that would bring her up to work in sustainable development. She is a student member of the Interuniversity Center for Aboriginal Studies and Research (CIÉRA) and of the Hydro-Québec Institute for the Environment, Development and Society (Université Laval). Her current research focuses on social interactions between indigenous and non-indigenous people in environmental management context.

Environmental Dashboards: Fostering Pro-environmental and Pro-community Thought and Action Through Feedback

John E. Petersen, Daniel Rosenberg Daneri, Cindy Frantz and Md Rumi Shammin

Abstract

Early humans experienced intimate and continuous feedback from the natural world that informed and constrained decision-making and helped individuals see themselves as part of larger wholes. This experience and perspective has been undermined by cultural, economic and ecological transformation. Characterization of universities as "ivory towers" reflects a parallel separation and alienation—a perceived disconnect between knowledge generation and practical application to solve societal challenges. This paper reviews how "environmental dashboard" is being used as a novel form of "ecofeedback" to engage educational institutions with the ecological and social communities in which they are embedded. The dashboard technology and approach incorporate three scales of feedback: (1) "building dashboards" dynamically display water and electricity consumption in individual buildings; (2) "citywide dashboards" animate whole community resource flows; (3) "community voices" combine images and words drawn from interviews to celebrate local thought and action that advance sustainability in diverse communities. A pilot implementation in Oberlin, Ohio displays all three components on digital signs in public spaces including schools, storefronts, community organizations and the Oberlin College

J.E. Petersen (✉) · D. Rosenberg Daneri · Md R. Shammin
Environmental Studies Program, Oberlin College, Oberlin, OH 44074, USA
e-mail: john.petersen@oberlin.edu

D. Rosenberg Daneri
e-mail: rosenberg.danny@gmail.com

M.R. Shammin
e-mail: rumi.shammin@oberlin.edu

C. Frantz
Psychology Department, Oberlin College, Oberlin, USA
e-mail: cindy.frantz@oberlin.edu

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_10

campus. We use this as a case study to explore how students and faculty have employed an educational model emphasizing civic engagement to develop and manage the technology and co-produce knowledge and content with the larger community. Research indicates that this technology enhances systems thinking, promotes energy and water conservation and stimulates content retention. The technology and findings are widely applicable to other communities that are now implementing environmental dashboard.

Keywords
Feedback · Technology · Electricity · Water · Conservation · Education · Collaboration · City · Engaged learning · Community based learning · Social norms · Sustainability

1 Introduction: Challenges and Changes in Environment, Society and Higher Education

1.1 The Loss of Feedback Related to Natural Resources and Its Implications

For the vast majority of the 50,000 years of modern human evolution, the decisions that people made as individuals and in groups were determined by intimate and relatively rapid feedback from the natural world around them. Indeed, humans' ability to successfully acquire food, fuel and fiber and to perpetuate genes to future generations was determined by their sensitivity to environmental cues. Over the last few centuries we have rapidly transitioned to a world in which the majority of the human population now lives in cities. North Americans now spend 90 % of their lives inside of buildings (Evans and McCoy 1998) and this statistic is likely similar in most of the developed world. Particularly in developed countries, our immediate experience with resource acquisition is that energy and water come from outlets and faucets, food and other material goods come from stores or markets, and waste goes down drains and into garbage containers. At best, what humans experience today is an opaque and weak form of feedback on consumption in the form of financial expenditures on goods and services. Today the environmental and human context and consequences of resource consumption are largely out of sight and unaccounted for and therefore out of mind.

Feedback can be defined as a causal loop in which the output of energy, material or information from one component of a system affects other components of the system through a network of causal links in ways that ultimately return or alter input(s) to the first component. In many ways, the origin of the modern environmental juggernaut faced today can be traced back to the positive feedback loop initiated when humans coupled their economies to the extraction and use of fossil

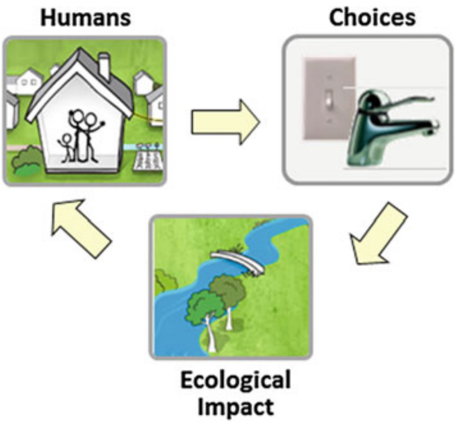


Fig. 1 Sociotechnical feedback and ecofeedback leverage technology to inform better decision-making by presenting information that highlights social, ecological and/or economic implications

fuels. As a result, the 20th century witnessed a transition in which humans assumed a dominant degree of control over global flows of energy and cycles of key materials such as water, carbon, nitrogen and phosphorus through the biosphere (Vitousek et al. 1997). Environmental scientists caution that this positive feedback is inherently limited in duration; continued growth in resource consumption and pollution production is impossible on a planet with finite materials, finite availability of renewable energy and finite capacity to assimilate pollutants. The work described in this paper is premised on the notion that transition to a more sustainable relationship with the natural world demands that we introduce new forms of feedback that bring resource flows back into sight, mind and decision-making. "Sociotechnical" feedback is an emerging class of information feedback in which technology is employed to acquire, process and deliver information that alters human thought and action. "Ecofeedback" refers to information feedback that is explicitly designed to communicate the environmental implications of decision-making in ways that reduce material and energy consumption and more generally promote pro-environmental behavior (Fig. 1).

1.2 The Role of the University in Social and Environmental Problem-Solving: Alternative Models

Addressing the deep-seated challenge of physical and psychological separation such that daily decisions are once again informed by their ecological and social implications requires a fundamental transformation at all levels of education including colleges and universities. Unfortunately, the separation of people from resource flows has occurred in parallel with (and some might argue as a partial result of) the growth of higher education. Yet it is important to recognize how different models of higher education are associated with very different goals and outcomes with respect to university-society-environment relationships. The four models described below illustrate the implications of these differences for social, economic and ecological problem-solving.

1. *Building an ivory tower*:

   One dominant model is the university as a place where knowledge exists as an end in itself. While developments at universities are invariably linked with larger social and economic forces, many in education have sought to separate and isolate the production and application of knowledge in the university from society as a whole. In the words of Cardinal John Newman, founder of University College Dublin in 1852, “the university is the high protecting power of all knowledge and science, of fact and principle, of inquiry and discovery, of experience and speculation” (Kerr 2001). The university was thus conceptualized as a producer, disseminator and arbiter of knowledge. This still dominant model emphasizes an objectification of the thing being studied—whether human or natural. It emphasizes distance between knowledge acquisition and application. It is problematic to the extent that it reinforces separation among individuals and societal organizations that must ultimately work together to solve pressing environmental and societal challenges.
2. *Fulfilling the needs of an industrial economy*:
   In response to rapid economic and technological developments in the 20th century associated with increased use of fossil fuel, a parallel model of university education has emphasized workforce preparation to meet the demands of a modern industrialized and consumer-based economy (Kerr 2001; Saltmarsh and Zlotkowski 2011). Certainly, the advancements in industry, technology, and science in the last century would not have been possible without universities that were responsive to national and international economic demand for particular suites of knowledge and skills. In the United States, the structure of the university was also strongly influenced by the demands of the Cold War and what U.S. President Dwight Eisenhower termed the “military-industrial complex” (Hollander et al. 2001). This model is fundamentally linked with economic systems premised on sustained consumption and growth in material and energy use. Ecological economists caution that this growth-based model is incompatible with the ecological realities of finite resources (Daly 1996).
3. *Learning through community engagement and service*:
   In the 1980s, the “service-learning” movement sought new relationships premised on deeply integrating community engagement with academic study (Hollander et al. 2001). Out of this movement came the concept of the “engaged university” in which universities align research, education and outreach with community needs (Whitmer et al. 2010) to serve the public good (Jacoby 1996; Rhoads 2003). This model is distinct from the first model in its emphasis on connecting rather than separating learning from society. It is distinct from the second model in its emphasis on addressing human needs rather than on promoting macroeconomic growth. Many colleges and universities have now developed curricular and extracurricular programs that emphasize student civic

engagement through community service, internship requirements, student teaching, and field experiences (Bringle and Hatcher 2002). While the service learning model has been lauded by many, it is not yet clear how this model, as currently exercised, might address the breadth of sustainability-related challenges faced by society.

4. *Promoting sustainability and fostering systems thinking*:
The last decade has seen the birth of a new and parallel focus on sustainability in higher education. Examples from around the world illustrate how universities are forming partnerships with their surrounding communities to advance mutual sustainability goals (König 1996; Rosenberg Daneri et al. 2015; Zilahy and Huisingh 2009). "Systems thinking" is both a set of skills and a worldview that is closely related to the concept of sustainability. Systems thinking can be defined as a way of conceptualizing the world that emphasizes relationships, interdependencies, circular causal chains and feedback between parts that form larger wholes (e.g. Capra and Luisi 2014); the systems thinker sees him or herself as an important and engaged agent simultaneously acting at multiple levels within this whole. A premise of the work described in this paper is that feedback technologies can be used to leverage the complementary power of civically engaged service learning (model #3) and systems thinking to better situate individual action in a community context that empowers change towards a more sustainable future.

2 Using Feedback to Change Thought and Behavior: What We Know

In her classic paper, "Leverage points: Places to intervene in a system" (recently republished as Meadows 2009) Donella Meadows argues that explicitly recognizing and then altering or inserting new information feedback is often the most effective and lowest cost mechanism for generating desirable systemic change. Over the last few decades there has been growing interest in the use of sociotechnical feedback as a mechanism for reducing resource consumption in buildings. Thus far, research has focused on the use of consumer-facing feedback on residential electricity use. Residential consumption is an important target because it accounts for 54 % of total building energy use in the U.S. (DOE 2012) and it has been estimated that behavior change could reduce household greenhouse gas emissions by 20 % by 2020 (Dietz et al. 2009). Several recent publications summarize findings on the general impact of feedback on residential electricity use. For example, a comprehensive meta- analysis that considered 170 prior studies concluded that the introduction of feedback generally stimulates households to reduce electricity consumption by between 4 and 12 % (Ehrhardt-Martinez et al. 2010). This success in the residential environment suggests that we might look for opportunities to improve and expand the use of feedback to motivate changes in thought and behavior at larger scales.

Sophisticated messaging that carefully considers psychological impact is critical to the delivery of feedback in ways that actually affect behavior. Six features that maximize the effectiveness of feedback have been identified and described (Petersen et al. 2014). Particularly important among these are usability; information must be easy to access, actionable and have an impact that the targeted individual can readily observe and make meaning out of. Leveraging social norms is likewise of great importance—messages are most impactful if they demonstrate that others, particularly those who are respected community members, are already exhibiting targeted pro-environmental and pro-community behavior. Messages in which people either state goals and commitments or encourage others to do so are likewise important. Effective information feedback should also be designed to assess emotional and less rational as well as rational modes of decision-making (e.g. Fig. 2).

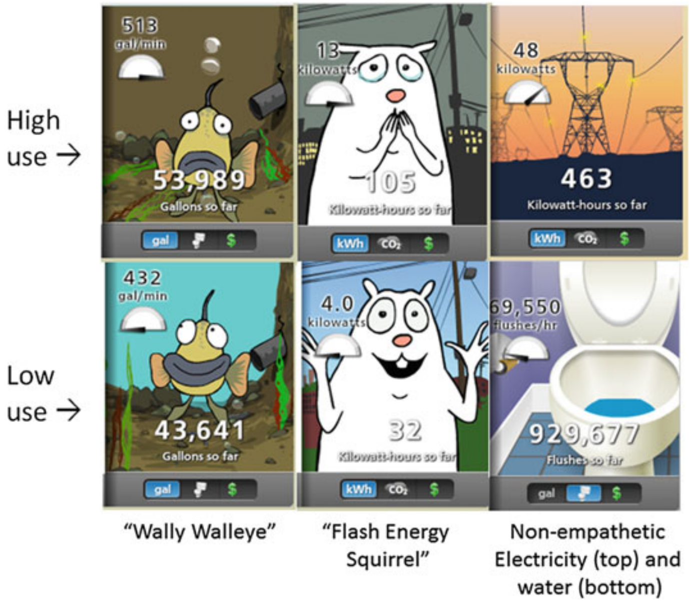


Fig. 2 "Empathetic gauges" are designed to stimulate an emotional response to resource consumption. Animated characters exhibit different emotions and behaviors depending on current levels of resource consumption relative to typical patterns of consumption (for example in the simplest case varying from smiling to frowning). Research conducted at Oberlin indicates that empathetic characters are generally more engaging and motivational that non-empathetic gauges that display identical quantitative information

3 Environmental Dashboards: Employing Multiple Scales of Feedback to Promote Systems Thinking

3.1 Concept and Goals

Comparison within and between monitored residential units and competition between units have proven to be effective means of stimulating reductions in electricity consumption (Ehrhardt-Martinez et al. 2010; Petersen et al. 2007). However, two important additional questions remain. First, do changes in thought and behavior resulting from this residential feedback extend beyond (spill over) the targeted resource? Second, are there approaches to delivering feedback that might substantially enhance and expand impacts on thought and behavior? With respect to spillover effects, recent research suggests that comparative feedback in the context of resource-reduction competitions can, in some cases, encourage new conservation behaviors unrelated to the behavior targeted. For example college students reported increases in activities such as recycling and bicycle riding in response to electricity and water use reduction competitions (Petersen et al. 2015).

The questions posed above are important because the transformations necessary to achieve more sustainable societies are likely predicated on cultural and psychological changes that extend well beyond altering consumptive behaviors of individuals. It can be argued that this transformation requires that individuals and communities engage in fundamentally new patterns of thought that emphasize systems thinking. Necessary transformation also requires multiples scales of behavior change that range from turning off unused appliances to voting for candidates and issues that support sustainability to more deeply engaging in community-building. Thus, any new feedback technology is integrally linked to the third and fourth models of university-society relationship described in the earlier section of this paper. Is it possible to expand the scale of feedback in ways that help facilitate social and ecological transformation? Over the last decade, researchers at Oberlin College have focused on developing a whole-community approach that employs multiple scales and multiple modes of feedback designed to engage, educate, motivate and empower communities to embrace sustainable thought and action across scales (Fig. 3). With grant support from funding agencies that include U.S. Environmental Protection Agency, the Great Lakes Protection Fund, Great Lakes College Association and the National Science Foundation, Oberlin College and the small city of Oberlin, Ohio (population of 8,000) have served as a testing ground for development of this technology.

"Environmental dashboard" (ED) is a technology and an approach to generating sociotechnical feedback that facilitates pro-environmental and pro-community thought and action. The promotion of systems thinking is a core goal of the technology. Four corollary goals include: (1) fostering a sense of connectedness and belonging between the individual and the ecological, social and economic community that the person inhabits; (2) expanding the capacity for individuals to situate personal decisions in a community context; (3) enabling bottom-up as well as top

Fig. 3 Environmental dashboard: Impacts of resource-use choices (*solid arrows*) can be made visible through multiple scales of feedback (*dashed arrows*). Building dashboard (*1*) and citywide dashboard (*2*) monitor and display resource flows and environmental conditions through individual buildings and whole communities; "community voices" (*3*) adds images and ideas contributed by community members

down information flow, for instance by empowering youth and other members of the community who may not currently have a strong public voice to meaningfully engage and share their ideas and actions and to function as agents of change; (4) changing thought in ways that result in multiple scales of behavior change so as to minimize individual and community resource consumption and maximize environmental benefits.

Environmental dashboard currently uses three primary modes of information delivery: websites, digital signage and "environmental orbs". The interactivity possible on a website provides the deepest and richest presentation of content and allows the user to determine the experience and the particular information gleaned. However, a critical barrier for information delivery via a website is that the local audience reached is limited to those who actively seek out content. Digital signage and orbs achieve the usability criteria of being visually prominent within the user's environment. The orb (Fig. 4) is an example of "ambient feedback"—experiential feedback within occupied spaces that communicates limited and potentially subliminal information that requires low cognitive processing. We have therefore restricted use of the orbs to displaying information related to water and electricity

Fig. 4 "Environmental Orbs" glow different colors and with different pulsing patterns to communicate whether current levels of electricity and water consumption within buildings are high or low relative to typical levels of use at this time of day. The one pictured is installed in the lobby of a student dormitory

Fig. 5 Environmental dashboard digital signs are installed throughout the Oberlin community, this one in the window of a popular cafe

use in individual buildings. In contrast, digital signage provides a context for publicly displaying much richer content.

Environmental dashboard digital signage can be installed in a range of public spaces so as to target the full diversity of a community (Fig. 5). Both the digital signage and websites combine three levels of feedback: (1) "building dashboard" (Fig. 6) dynamically displays water and electricity consumption in individual buildings within communities; (2) "citywide dashboard" (Fig. 7) is a conceptual model of a city dynamically animated with real-time data on water and electricity flows and water and weather quality; (3) "community voices" (Fig. 8) combines images and text drawn from the full diversity of a local community to celebrate pro-environmental thought and action already underway.

Thus far deployments of digital signage in the city of Oberlin and in Oberlin College have emphasized non-interactive digital signage (Fig. 5) that rotates

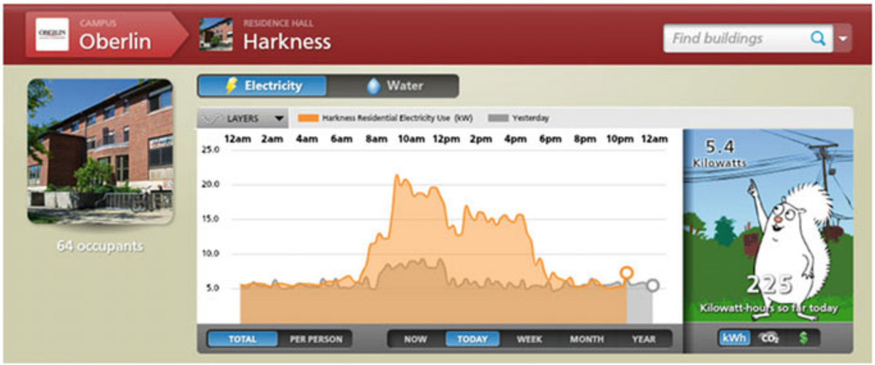


Fig. 6 Building dashboard displays make information on resource use accessible and engaging to non-technical building occupants: current patterns are compared with past performance and among buildings; empathetic character gauges animate in response to resource consumption, imbuing quantitative data with emotional resonance (also see Fig. 2). Originally prototyped at Oberlin, by 2015 building dashboard technology, now marketed by Lucid, was installed in over 10,000 buildings across the United States and Canada

through a sequence that includes building dashboard, citywide dashboard, community voices, community calendars and site-specific content particular to each screen location. For example, a display in Oberlin's public library consists of a sequence that includes a building dashboard that displays patterns of water and electricity use within the library facility itself, citywide dashboard, community voices, a community-wide calendar, promotional content for events taking place at the library, and a feature on environmentally related books at the library. Dashboard signage has now been installed in seven locations on Oberlin College campus and eleven locations within the city including in all four public schools, four nonprofit organizations and three businesses.

3.2 Implementation: Developing Content for Community Voices

As discussed above, the goal of the community voices component of ED is to discover, communicate and strengthen pro-environmental and pro-community thought, action and identity. Community voices is premised on an understanding that most people are already engaged in a variety of thought and action in their daily lives that can serve as the basis for further transformation towards the goal of social, economic and ecological sustainability. Community voices also embraces diversity to highlight and leverage the unique history and character of a particular community so as to foster pride in accomplishments and encourage further aspiration.

The text and photographs that are used to generate content for community voices are gathered through a process that is entirely distinct from the collection of real-time data employed in the other two components of ED. Goals of content

Fig. 7 Citywide dashboard. An animated display of real-time electricity and water use and environmental conditions in entire communities or organizations. Gauges and animations of water flowing through pipes and electrons flowing down power lines reveal how decisions made in our homes and workplaces are reflected in city-wide patterns and conditions. Messages delivered by "Wally Walleye" and "Flash the Energy Squirrel" narrate the story of current resource use. Real-time data for the displays are accessed directly from the public electrical and water utility companies. The goal is to situate individual decision-making in a community and systems context

featured include: representing the full diversity of the community (racial, cultural, economic, etc.), fostering a broader understanding of the concept and goals of sustainability (without necessarily using the term), sharing positive thoughts and actions in order to generate a pro-environmental and pro-community identity and a shared vision of a sustainable and resilient future. Text content is developed through interviews, historic archives and public documents. Images are contributed by community members and taken from historic archives. The Oberlin team has developed six categories of content to highlight distinct contributions to sustainability:

1. "Neighbors" features quotes from members of a community who are, through their personal examples, exhibiting pro-environmental and pro-community behaviors in their homes, backyard, gardens, neighborhoods, etc. The goal is to reinforce positive social norms.
2. "Heritage" includes images and words reflective of a community's legacy of stewardship and engagement on a range of issues. Viewers experience how the environmental challenges and leadership opportunities that a community faces today build on past success.

Fig. 8 Sample content from four of the categories within community voices. The database for the Oberlin community has many hundreds of images that are selected for display on public screens at any time based on a designated probability of occurrence. A strong emphasis is placed on neighbors, children, nature, community service and local economic development

3. "Our Downtown" includes commitments and environmental thoughts of those who own and work in local businesses.
4. "Natural Oberlin" includes images and words that relate to the natural and cultivated beauty of a community. Photographs and artwork serve to reinforce interconnectivity and sense of pride and belonging to ecological place.
5. "Serving our Community" features the sustainability related work of community organizations, public schools and city government workers.
6. "Next Generation" features words and often artwork by and about children in the community. This category recognizes children as important agents of change within a community who are not often provided with a public voice.

Photographs, text, and designated category are combined with a category title and an associated icon for display (Fig. 8).

3.2.1 Generating Messages that Promote Pro-environmental and Pro-community Thought and Behavior

Research in social psychology, marketing and communication has revealed a set of principles that can be used to elicit and select content so as to maximize positive impact on thought and action (Ardoin et al. 2013; Cialdini 2009; McKenzie-Mohr and Smith 1999). The following eight principles are derived from this research and are being used to inform the development of interview questions and the selection of text and image content:

1. Focus on stories that are personal, local and connected. This includes emphasizing specific actions people are taking within the community, featuring local environmental burdens and benefits, emphasizing relationships between local economy, ecology and community and connecting local with global.
2. Celebrate positive thought and action. This includes emphasizing solutions rather than problems, appealing to people's desire to be "good people", featuring images that convey pleasure and pride and capture pro-environmental and pro-community action.
3. Feature diversity. This entails including content that represents and resonates with different groups in a community that possess distinct values and worldviews. It includes featuring groups who are not commonly heard from and non-traditional as well as traditional leaders. Every viewer should see "someone like me" represented.
4. Leverage social norms and satisfy people's desire to belong. This means highlighting the work of diverse groups that community members associate themselves with, demonstrating that a broad range of individuals are exhibiting target thought and behavior and helping people to understand that their efforts are part of a larger effort.
5. Feature commitments and goals. These highlight positive commitments individuals are making to improve themselves, their families, their community, the environment and the local economy. It likewise means featuring public commitments, goals and rationales made by NGOs, businesses, schools and the government as well as by individuals.
6. Emphasize positive consistency in thought and action. This includes prompting people to engage in actions that are consistent with whatever pro-environmental and pro-community values and worldviews to which they already subscribe. It means demonstrating how solutions are aligned with common values and priorities of community members.
7. Appeal to self-interest, convenience and personal health as well as community interest. This includes featuring benefits to individuals, families and community. It means featuring circumstances in which sustainable choices are also convenient, economical and healthy.
8. Select engaging images and messages. This includes content that catches the eyes of audience, elicits emotional and empathetic responses, provokes thought, empowers positive action, and avoids preachiness, condescension, political partisanship, and exclusionary connotations.

Interview questions and follow up questions have been explicitly designed to elicit content that meets these eight criteria. As discussed further below, Oberlin College students have played the principal role in conducting interviews and have done this in the context of a variety of classes and independent projects focused on developing communication and research skills.

3.3 Integration with Teaching and Learning at Oberlin College

Educational models #3 and #4 have been fundamental to the development of ED. Educational goals include developing college students' communication and research skills such as interviewing, archival research, public presentation, community organizing and grant writing. These skills have been cultivated by actively engaging students in developing and managing all components of ED and this experience has often placed them in collaborative relations with residents of the larger Oberlin Community. An expanding range of classes have begun to further integrate ED into their pedagogy. These have ranged from introductory through advanced courses and now encompass courses in academic departments that include environmental studies, sociology, anthropology, religion, theatre, biology, computer science, education and women and gender studies.

The ongoing process of developing new content for the community voices component has provided particularly rich and interesting opportunities related to both pedagogy and city-college collaboration. Student participation in interviews of community members provide an unusual and valuable context for challenging typical models of university-society exchange. College and university students who choose to engage in service learning are generally eager to disseminate knowledge—that is to share and apply skills, information and insights that they develop through their studies. The process of conducting interviews for community voices inverts this model of information transfer in an important way by placing students in the position of receiving rather than delivering knowledge. Students who have experienced this inversion report that they gain significant and valuable insights; they are often quite humbled by what they learn from community members, many of whom are rich in life and career experience while sometimes shorter in experience with higher education. For the community members as well, the experience of having their ideas and insights listened to and valued by these college students and by the faculty involved in the project does much to improve their view of higher education and "town-gown" relationships.

3.4 Integration with Teaching and Learning in Oberlin Public Schools

Collaborations between college faculty, college students and teachers and administrators in the Oberlin public schools have focused on curriculum development, on creation of content in the "Next Generation" category for community voices and on resource use reduction competitions among the four public schools. With respect to curriculum development, a variety of lessons have been developed that use ED to teach content associated with the existing topics and standards and to enhance the development of systems thinking skills. For example, building dashboard and citywide dashboard have been used to teach lessons focused on stream water quality in the fifth grade, electrical circuits in the fourth and fifth grade and algebra,

Fig. 9 Students in Oberlin's Langston Middle School using environmental dashboard to study water quality in the local watershed

environmental science and consumer science in the high school (Fig. 9). Text and artwork drawn from students in all four schools has been extensively incorporated into the community voice display. With the goal of better integrating systems thinking skills into school curriculum, faculty at Oberlin College led a workshop for 10 local teachers in the summer of 2014 to support learning in subjects ranging from social studies to math and pre-engineering. Collaboration is ongoing between college faculty, college students and faculty and administrators in the public schools.

In the spring of 2014 and 2015 building dashboard was used to hold two successful inter-school resource use reduction competitions concurrent with annual resource reduction competitions held among Oberlin College dormitories since 2006. Competitions have likewise proved to be an exceptional opportunity for collaboration between college faculty and students and the students, faculty and administrators in the public schools; college students work to organize the competitions by: teaching short lessons relating to using and understanding ED and sustainability in the public schools, organizing city-college events, and working with children to create promotional materials. In both years Prospect Elementary (grades 3–5) achieved over 30 % reductions in electricity use which is indicative of the extraordinarily high level of engagement in that school on the part of students, faculty and staff (Fig. 10).

3.5 Research on Environmental Dashboard

A comprehensive research program within and beyond the Oberlin community combines direct user testing with surveys to carefully assess the efficiency of all three components of ED. For example, the Oberlin research team partnered with Lucid, the National Wildlife Federation, the U.S. Green Building Council and the Alliance to Save Energy to develop and assess "Campus Conservation Nationals"—an annual event using resource reduction competitions in dormitories to promote conservation and environmental leadership. Direct measures of resource savings

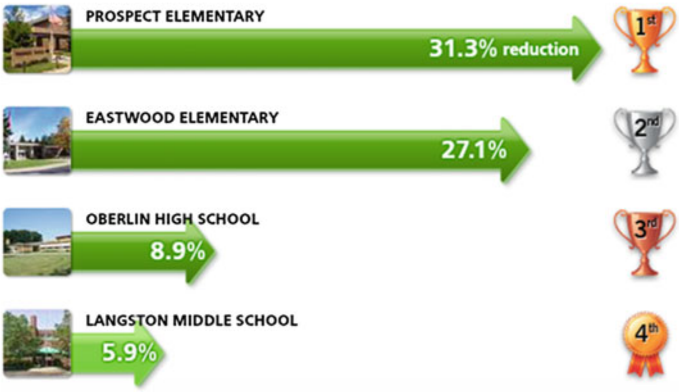


Fig. 10 Results of 2015 resource reduction competition among Oberlin City Schools

combined with extensive survey work revealed that feedback from building dashboard in combination with competition lead to significant behavior change and reductions in resource use in college dorms (Petersen et al. 2007, 2015). Research is now focused on both citywide dashboard and community voices, with particular emphasis on better understanding impacts on systems thinking skills and differences in the impact of messages attributed to adults and children. A sample of findings are included below.

3.5.1 Effect of Citywide Dashboard on Systems Thinking

Three separate studies have been conducted to test the extent to which systems thinking is affected by exposure to citywide dashboard. In these studies, a sample of college students and a sample of adults from across the U.S. were regularly exposed to citywide dashboard (Fig. 7). Viewers of citywide dashboard were compared with a group exposed to a display that contained identical information and similarly engaging animations but without the conceptual model of resource flow through the community. Results indicated that several dimensions of systems thinking were enhanced by exposure to citywide dashboard including degree of connectedness with nature (assessed using the scale of Mayer and Frantz 2004), perception of community as an ecological system and perceptions of causal linkages and responsibility (assessed using the approach of Maddux and Yuki 2006). These findings suggest that systems thinking can, in fact, be increased by exposure to conceptual models animated with real-time feedback.

3.5.2 Effects of Lessons Using Environmental Dashboard on Content Retention and Systems Thinking

Prior research suggests that systems thinking can be explicitly taught in a classroom setting (e.g., Hipkins et al. 2008). However, to date research has generally focused on older children and adults, and has been primarily observational. To assess the potential use of ED to support learning in K-12 schools and to improve systems thinking, the dashboard research team conducted a study that used building dashboard and citywide dashboard components to support 4th and 5th grade units on electricity in an Oberlin elementary school. Children in classrooms that received instruction using ED showed enhanced systems thinking skills, content retention and self-efficacy compared to a control group that received normal instruction that did not incorporate the technology (Clark et al. in review).

3.5.3 Effects of Community Voices

Research is currently underway to assess the effectiveness of community voices. Preliminary studies conducted on samples from the U.S. Population indicate that exposure to community voices significantly enhances people's level of concern for the environment and commitment to taking action on environmental issues. Targeted research has also been conducted to assess whether the same message attributed to and associated with images of adults versus children has different impacts. Preliminary findings indicate that differences in the effect of messages attributed to adults versus children are relatively small and depend on the measure being assessed. Current research is also assessing the impact of being interviewed and featured on community voices. It is hypothesized that this experience may enhance the interviewees sense of connection to community, connectedness to nature, self-efficacy and self-reported conservation behavior.

3.5.4 Impact of Exposure to Digital Signage

Prior to installation, extensive survey work was conducted in 2012 at each of the sites within the community in which ED digital signage has been installed to collect baseline data related to a range of psychological metrics associated with systems thinking and views towards the environment and community. Follow-up surveys to assess the impact of exposure are planned for 2016.

3.6 Expansion of Environmental Dashboard to Other Communities

The Oberlin team is in dialogue with numerous other communities throughout the U.S. and Canada who have expressed interest in developing their own environmental dashboards. The building dashboard component is commercially available and actively marketed by Lucid. As of summer 2015 this component was already installed in 150 colleges (3,000 campus buildings) and 650 K-12 school buildings. In the fall of 2014, Oberlin College—in partnership with Albion College, Antioch College, DePauw University, and Hope College—was awarded a grant from the Great Lakes College Association (GLCA) as part of their "Expanding Collaboration Initiative," funded by the Andrew W. Mellon Foundation. The project's purpose is to use ED to foster programs of teaching, research, and outreach across college campuses to heighten awareness of how human behaviors affect the well-being of the natural environment, as well as the sustained vitality of human society in local settings and the broader global context. As of this writing building dashboard has been installed in select buildings on each of these campuses, community voices content is being developed by each institution that is specific to each community and two of the institutions are actively engaged with their local communities in scoping the feasibility of developing the citywide dashboard component. The Oberlin research team is enthused about the much larger collaborative group now focused on researching and further developing environmental dashboard as a technology that connects colleges and universities with the communities in which they are embedded.

4 Conclusion

Universities possess powerful intellectual and financial resources for developing and advancing solutions to pressing environmental, social and economic challenges. Given their credibility and role as repositories of expertise on a wide range of issues, they are also well-positioned in society to facilitate interaction and coordination among different entities. At the same time, the historical legacy of higher education as both “ivory towers” (educational model #1) and as tools of government and industrial policy (model #2) create certain barriers to fulfilling this role. Over the last several decades, the increased emphasis on community-based and civically engaged learning (model #3) has done much to overcome these barriers at institutions that have pursued these approaches. The emerging focus of both cities and universities on researching and promoting economic, social and environmental dimensions of sustainability is creating new opportunities for further engagement (model #4). This paper has described the roles that the technological tools and approaches embodied in environmental dashboard might play in advancing town-gown collaboration and transformation. While it is early to draw broad conclusions, the Oberlin pilot and work in other communities suggests that approaches like this can, indeed, harness social psychology, technology and culture to inform the design of novel forms of feedback that reconnect people with resource flows and inform better decision-making. Engagement in this kind of research and application also provides students with authentic and meaningful educational experiences that situate their learning in a larger community context. Furthermore, environmental dashboard offers rich opportunities for engaging a variety of stakeholders to support sustainability measures. By inviting an entire city to collaborate using a common and accessible digital platform, the dashboard may facilitate coordination and help create a shared vision of a more sustainable future.

References

Ardoin, N., Heimlich, J., Braus, J., & Merrick, C. (2013). *Influencing conservation action: What research says about environmental literacy, behavior, and conservation results*. New York, NY: National Audubon Society.

Bringle, R. G., & Hatcher, J. A. (2002). Campus-community partnerships: The terms of engagement. *Journal of Social Issues, 58*(3), 503–516.

Capra, F., & Luisi, P. L. (2014). *The systems view of life: A unifying vision*. Cambridge, UK: Cambridge University Press.

Cialdini, R. B. (2009). *Influence: Science and practice*. Boston, MA: Allen and Bacon.

Daly, H. E. (1996). *Beyond growth: The economics of sustainable development*. Boston, MA: Beacon Press.

Dietz, T., Gardner, G. T., Gilligan, J., Stern, P. C., & Vandenbergh, M. P. (2009). Household actions can provide a behavioral wedge to rapidly reduce U.S. carbon emissions. *Proceedings of the National Academy of Sciences of the United States of America, 106*(44), 18452–18456.

DOE. (2012). 2011 buildings energy data book. http://buildingsdatabook.eren.doe.gov. Buildings Technologies Program, Energy Efficiency and Renewable Energy, U.S. Department of Energy, Washington, DC.

Ehrhardt-Martinez, K., Donnelly, K. A., & Laitner, J. A. (2010). *Advanced metering initiatives and residential feedback programs: A meta-review for household electricity saving opportunities* (p. 140). Washington D.C.: American Council for an Energy-Efficient Economy.

Evans, G. W., & McCoy, J. M. (1998). When buildings don't work: The role of architecture in human health. *Journal of Environmental Psychology, 18*, 85–94.

Hipkins, R., Bull, A., & Joyce, C. (2008). The interplay of context and concepts in primary school children's systems thinking. *Journal of Biological Education, 42*(2), 73–77.

Hollander, E., Saltmarsh, J., & Zlotkowski, E. (2001). Indicators of engagement. In L. A. Simon, M. Kenny, K. Brabeck, & R. M. Lerner (Eds.), *Learning to serve: Promoting civil society through service-learning* (pp. 31–49). MA: Kluwer Academic Publishers, Norwell.

Jacoby, B. (1996). *Service-learning in higher education*. San Francisco, CA: Jossey-Bass Publishers.

Kerr, C. (2001). *The uses of the university*. Cambridge, MA: Harvard University Press.

König, A. (Ed.). (1996). *Regenerative sustainable development of universities and cities: Role of living laboratories*. Cheltenham, United Kingdom: Edward Elgar.

Maddux, W. W., & Yuki, M. (2006). The 'ripple effect': Cultural differences in perceptions of the consequences of events. *Personality and Social Psychology Bulletin, 32*(5), 669–683.

Mayer, S. F., & Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of Environmental Psychology, 24*, 503–515.

McKenzie-Mohr, D., & Smith, W. (1999). *Fostering sustainable behavior: An introduction to community based social marketing*. Gabriola Island B.C., Canada: New Society Publishers.

Meadows, D. H. (2009). Places to intervene in a system. *Solutions, 1*(1), 41–49.

Petersen, J. E., Frantz, C., & Shammin, R. (2014). Using sociotechnical feedback to engage, educate, motivate and empower environmental thought and action. *Solutions, 5*(1), 79–87.

Petersen, J. E., Frantz, C. M., Shammin, M. R., Yanisch, T. M., Tincknell, E. & Myers, N. (2015) Electricity and water conservation on college and university campuses in response to national competitions among dormitories: Quantifying relationships between behavior, conservation strategies and psychological metrics. *PlosOn*. doi:10.1371/journal.pone.0144070

Petersen, J. E., Shunturov, V., Janda, K., Platt, G., & Weinberger, K. (2007). Dormitory residents reduce electricity consumption when exposed to real-time visual feedback and incentives. *International Journal of Sustainability in Higher Education, 8*(1), 16–33.

Rhoads, R. A. (2003). How civic engagement is reframing liberal education. *Peer Review, 5*(3), 25–28.

Rosenberg Daneri, D., Trencher, G., & Petersen, J. (2015). Students as change agents in a town-wide sustainability transformation: The Oberlin Project at Oberlin College. *Current Opinions in Environmental Sustainability, 16*(1).
Saltmarsh, J., & Zlotkowski, E. (2011). *Higher education and democracy: Essays on service-learning and civic engagement*. Philadelphia, PA: Temple University Press.
Vitousek, P. M., Mooney, H. A., Lubchenco, J., & Melillo, J. M. (1997). Human domination of Earth's ecosystems. *Science, 277*(5325), 494–499.
Whitmer, A., Ogden, L., Lawton, J., Sturner, P., Groffman, P. M., Schneider, L., et al. (2010). The engaged university: Providing a platform for research that transforms society. *Frontiers in Ecology and the Environment, 8*(6), 314–321.
Zilahy, G., & Huisingh, D. (2009). The roles of academia in regional sustainability initiatives. *Cleaner Production, 17*(12), 1057–1066.

Author Biographies

John E. Petersen is Professor of Environmental Studies at Oberlin College. A systems ecologist by training, Dr. Petersen's research and teaching focus on quantifying flows of energy, cycles of matter and control mechanisms operating in complex socio-ecological systems.

Daniel Rosenberg Daneri served as Project Manager of Environmental Dashboard from 2013 to 2015. As a PhD student in Cornell University's Department of Natural Resources, his work focuses on small-scale urban environmental stewardship movements (civic ecology) and how they impact larger community-level change.

Cindy Frantz is a professor of psychology at Oberlin College. Her research focuses on potential for feedback technology to encourage conservation behavior, connect humans back to the natural world, and promote systems thinking.

Md. Rumi Shammin is Associate Professor and Chair of the Environmental Studies Program at Oberlin College. His research interests focus on household energy consumption, behavior, ecological economics, urban sustainability and environmental issues in developing countries.

The Implementation of Sustainable Development in the Nordic Higher Education Institutions (HEIs)

Meeri Karvinen, Ullika Lundgren, Helena Mälkki and Jaana Sorvari

Abstract

Education has a key role in sustainable future. Due to their high societal impact, universities are challenged to take a leadership role in promoting sustainability. Although many Nordic HEIs have made efforts to integrate sustainability into their operations, the current status of sustainability has remained unexplored. This paper describes how the Nordic HEIs have studied the status of sustainability by implementing a joint project in the Rio+20 framework. The project included a wide survey on the implementation of Rio+20 goals targeted to the university staff, and three interactive workshops on drivers, indicators and implementation. The results provide an insight on how the Nordic HEIs implement sustainability, highlighting the key drivers, barriers and ways to promote sustainability. Finally, the project recognized and initiated new topics for collaboration around indicators and sustainability literacy to assure the continuity of the intensive collaboration between Nordic universities. This paper encourages universities globally to find areas for collaboration and to strive together to reach more sustainable societies.

M. Karvinen (✉) · H. Mälkki · J. Sorvari
Department of Built Environment, Aalto University School of Engineering, Rakentajanaukio 4, 02150 Espoo, Finland
e-mail: meeri.karvinen@aalto.fi

H. Mälkki
e-mail: helena.malkki@aalto.fi

J. Sorvari
e-mail: jaana.sorvari@aalto.fi

U. Lundgren
Centre for Environment and Sustainability, University of Gothenburg, Aschebergsgatan 44, 40530 Gothenburg, Sweden
e-mail: ullika@gu.se

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_11

Keywords
Rio+20 · ESD · Campus greening · Nordic HEIs · Sustainability

1 Introduction

Education was internationally recognized as one of the key measures to manage and promote environmental protection already in the United Nations (UN) Environmental Program's (UNEP) Stockholm Conference in 1972 (UNEP 1972). The UN has thereafter emphasized the role of education in every outcome document of its world summits on sustainable development (WSSD). Higher education was addressed particularly in the outcome document "The Future We Want" of the "Rio +20" WSSD in 2012, emphasizing the enhancement of transparent and effective governance, as well as commitment of decision-makers to implement sustainable development (SD) in all university operations (United Nations 2012). The role of higher education in enabling the change is apparent also in the goals of UN's Global Action Plan, the GAP (United Nations 2014), which followed the Decade of Education for Sustainable Development 2005–2014 (United Nations 2006).

Higher education institutions (HEIs) have for decades implemented sustainable actions in their operations (Wright 2002; Lozano et al. 2013). To communicate the engagement, HEIs have signed numerous voluntary declarations (Lozano et al. 2013). The most recent commitment, the Rio+20 Higher Education Sustainability Initiative (HESI 2012), consists of integrating SD into research, campus operations, teaching and outreach, being thus the first declaration to include an aspect of education for sustainable development (ESD).

The Nordic countries, including Denmark, Finland, Iceland, Norway and Sweden, are renowned for their socio-economic model embracing equality, high-level education and research, technological development and SD (Maassen et al. 2008). The region is additionally considered highly innovative and competitive (Nordic Council of Ministers 2010; European Commission 2015). Although the region has enhanced sustainability collaboratively for decades, and targets at leading the way in ESD (Nordic Council of Ministers 2009, 2011), the Nordic HEIs were lacking organized collaboration around SD until 2012, when Aalto University and the Universities of Copenhagen, Gothenburg, Iceland and Oslo established the Nordic Sustainable Campus Network (NSCN). NSCN gathers together sustainability experts working in the Nordic HEIs to share experiences in the framework of greening the campus and ESD. The Nordic Council of Ministers (NCM) provided financial support for the establishment of NSCN, which currently comprises 42 Nordic HEIs.

Twelve Nordic HEIs have signed the Rio+20 HESI initiative. Furthermore, both Nordic and national strategies have been recognized to include targets for ESD to implement UN commitments (Holm et al. 2012). However, comprehensive knowledge from the Nordic HEIs is lacking on how the strategies, and targets defined in the Rio+20 WSSD and Rio+20 HESI initiative, are implemented. Therefore, the founding members of the NSCN, KTH Royal Institute of Technology (Sweden), and Lappeenranta University of Technology (Finland), carried out a project called "Rio+20 implementation in the Nordic HEIs". Aalto University coordinated the NCM-funded project during 2014–2015. The project aimed at understanding how the Nordic HEIs approach sustainability in their operations, and recognizing the central drivers and barriers in the implementation of SD. This paper presents the main findings of the survey and workshops realized in the project, and discusses the future prospects in promoting SD in the Nordic HEIs.

2 Theoretical Framework

Universities educate the next generation of decision-makers and influencers. Therefore, universities can have a vastly greater impact on SD than any other single sector of society (Chambers 2009). Many authors have identified the need for an institutional approach to sustainability to enhance the integration of SD in higher education (Cortese 2003; Koester et al. 2006; Lozano 2006a; Mcmillin and Dyball 2009). Cortese (2003) defined a university system to consist of four dimensions (education, research, university operations and external community), underlining the necessity to understand the interdependence among these dimensions in achieving a transformative change. It seems, according to literature reviews by Ramos et al. (2015) and Wals (2014) that universities have moved towards better levels of sustainability integration during the past decades, but the development concerns widely the improving of the ecological footprint of a university, while measures to promote ESD are only emerging.

Some of the measures investigated recently include awareness-raising (Barth and Rieckmann 2012), recognizing key competences and embedding sustainability aspects into learning outcomes of courses (Svanström et al. 2008). Additionally, integrating ESD through audited systems, such as universities' quality assurance system (Holm et al. 2014) and an environmental management system EMS (Sammalisto 2007), is an emerging field especially in the Nordic countries. According to Sammalisto and Brorson (2008), an EMS promotes the integration particularly through the communications and training of university staff during its establishment process.

However, many challenges exist in the integration of ESD, specifically overcrowded curricula and limited teacher qualifications (Jones et al. 2008; Læssøe et al. 2009), limited resources and low commitment of university management (Leal Filho 2011). According to Sammalisto (2007), top management has a key position in the change towards SD—management should have a vision on future development and an understanding of SD. The literature review by Holm et al. (2015) supports this conclusion, finding committed management one of the key drivers for ESD. Ferrer-Balas et al. (2008) argued, however, that good leadership alone is insufficient in reaching a transformative change, which requires additional drivers, such as incentive structures, good coordination and societal pressure. Moreover, numerous other factors have been recognized to promote ESD, including both top-down (clear vision, strategy, indicators, coordination), and bottom-up mechanisms (interdisciplinary research and projects, collaboration, motivated individuals) (Velazquez et al. 2005; Ralph and Stubbs 2014; Cebrián et al. 2015; Holm et al. 2015).

The Nordic countries have had a joint strategy for SD since 2001, in which the role of higher education in promoting ESD is emphasized (Nordic Council of Ministers 2013). However, Sweden is the only country steering sustainability in HEIs through governmental actions; the Higher Education Act from 2006 states that universities shall promote SD in their activities. There is also a regulation on environmental management in government agencies, which has led to many Swedish universities establishing a certified EMS (Sammalisto 2007). A majority of research concerning SD in the Nordic HEIs has concentrated on Swedish case examples, which support the role of good leadership, clear strategy, EMS and collaboration in successful integration of SD (Sammalisto 2007; Holm et al. 2012; Holmberg et al. 2012). However, also international and Nordic comparative studies on SD in campus operations and teaching are available (Ferrer-Balas et al. 2008; Segalas et al. 2009; Eriksson et al. 2014).

Despite many SD-related and cross-institutional measuring tools and rating systems exist (Shriberg 2002; Lozano 2006b; Roorda and Martens 2008; Lozano and Peattie 2009; Dahl 2012), comparing sustainability performance is not an easy task. The project thus concentrated on investigating sustainability at a very general level, using selected indicators to represent the focus areas of SD and two dimensions of the Rio+20 HESI initiative, namely the NSCN-supported areas of campus operations and teaching.

3 Research Methods and Methodology

3.1 The Project Survey

The project started with surveying the views of Nordic university staff on the integration of SD and its drivers and barriers. The survey was implemented as an online questionnaire using Webropol in October–November 2014, and distributed to all Nordic HEIs through national SD-networks, the presidents of the HEIs, NSCN mailing-list and website, The Nordic Association of University Administrators' (NUAS) LinkedIn-group, and the NCM's channels.

The respondents identified drivers and barriers by open-ended questions. The institutions' sustainability was estimated using Likert-type scales on given statements related to focus areas of SD, campus operations and teaching. The scales used were:

– In focus areas: 1 = Core issue of my institution, 2 = Important issue for my institution, 3 = Not urgent and can wait for implementation
– In overall level of SD integration: 1 = Not at all integrated, 2 = Integration in a starting stage, 3 = Planning stage, 4 = Operational stage, and 5 = Institution has reached its targets
– In campus operations and teaching: 1 = Entirely disagree, 2 = Mostly disagree, 3 = Do not agree or disagree, 4 = Mostly agree 5 = Entirely agree.

The focus areas and assessed statements were defined by the partners and the steering committee of the project, consisting of 15 sustainability experts working in the Nordic HEIs and the Finnish Ministry of the Environment. In order to limit the answering-time, and to receive responses from the experts on the particular issues, some questions were targeted only to specific respondent groups, e.g.: the administrative staff did not participate in the ESD-related evaluations, drivers and barriers, and teachers in the campus operations-related assessments. All findings of the survey were compiled into a comprehensive survey report (Karvinen et al. 2015), keeping the institutions and respondents unidentified.

3.2 The Workshops

The project included three events for collecting information, sharing of experiences and promoting the integration of SD: the Copenhagen, Gothenburg and Oslo workshops (Table 1). These workshops included high-level presentations on global sustainability targets and the Rio+20 process in order to distribute information on the global SD-agenda. In the Copenhagen workshop, the same scale was used as in the questionnaire to evaluate the overall level of SD integration.

3.3 Limitations

The methods used in the project were chosen to support NSCN focus areas, excluding widely two dimensions from the Rio+20 framework, namely research and outreach. The indicators in the survey were additionally generalized, providing only an overview of SD in the Nordic HEIs rather than detailed information. Moreover, the channels used in distributing the survey were insufficient in reaching a representative sample of the whole Nordic university community, and are additionally mostly targeted at staff members already interested in sustainability. Thus, the authors acknowledge that the views of the respondents may be biased in this respect. Furthermore, since the questions concerning SD in campus operations and teaching were evaluated partly by different respondent groups, the results from

Table 1 The details on the target groups, aims and methods of each project workshop

Workshops of the Nordic "Rio+20"-project				
Name and place of the workshop	Duration	Target group	Aim of the workshop	Methods used
Copenhagen workshop at the University of Copenhagen, Denmark, Oct 2014. Arranged as a part of Making Universities Sustainable Conference arranged by the International Alliance of Research Universities (IARU)	90 min	Nordic and international university staff members working with sustainability	To survey the level of SD integration in universities globally and to explore, which drivers and barriers are affecting the integration, coming up with suggestions to promote SD	Short introductory presentations on drivers, and group work with prepared tasks, facilitated by a project partner
Gothenburg workshop at the University of Gothenburg, Sweden: "If you can't measure it, you can't manage it—is this true?" May 2015	2 full days	Nordic university staff members responsible for sustainability/environmental issues	To benchmark Nordic universities' measuring, reporting and managing practices relating to SD, and to identify new areas for Nordic collaboration, especially around indicators	Case example—presentations and interactive group work with prepared tasks
Oslo Workshop at the University of Oslo, Norway, Nov 2015	1, 5 days	Nordic university staff members and students involved with or interested in sustainability in Nordic HEIs, and other relevant stakeholders	To present an overview on Nordic HEIs' sustainability, summarize the "Rio+20"-project and to plan how to use the results of the survey at national, Nordic and international levels	Keynotes on SD in higher education, case examples on strategy, teaching and student engagement, and group work first in national, then in mixed groups

these questions are incompletely comparable. The views of different respondents within a respondent group may also vary, which was excluded from the analyses and the focus of this paper.

4 Results

4.1 The Number of Institutions and Experts Engaged in the Project

The project reached numerous Nordic HEIs and their staff members, i.e. practitioners and teachers, to collaborate around sustainability in the Rio+20 framework (Table 2). In total, 59 Nordic and six international HEIs, and ten other stakeholders took part in the project workshops and the survey (Table 2). Since every workshop

Table 2 The number of participants in each project activity, and the list of HEIs involved in the project

Number of participants in the four project activities	
1. The project survey	152 respondents from 52 Nordic HEIs
2. Copenhagen workshop	24 participants from 10 Nordic and 4 international HEIs
3. Gothenburg workshop	27 participants from 13 Nordic and 1 international HEIs
4. Oslo workshop	47 participants from 26 Nordic and 1 international HEIs
The higher education institutions involved in the project	
Denmark	Oslo and Akershus University College of Applied Sciences
Aalborg University	Oslo College University
Copenhagen Business School CBS	Rudolf Steiner University College, Norway
Roskilde University	University of Agder
Technical university of Denmark DTU	University of Bergen
University College Zealand	University of Oslo
University of Copenhagen	
	Sweden
The Faroe Islands	Blekinge Institute of Technology
University of the Faroe Islands	Chalmers University of Technology
	Halmstad University

(continued)

Table 2 (continued)

Finland	Jönköping University
Aalto University	Karolinska Institute
Arcada University of Applied Sciences	Kristianstad University
Hanken School of Economics	KTH Royal Institute of Technology
Helsinki Metropolia University of Applied Sciences	Linnaeus University
Karelia University of Applied Sciences	Lund University, Sweden
Lahti University of Applied Sciences	Mid Sweden University
Lappeenranta University of Technology	Stockholm University
Laurea University of Applied Sciences	Södertörn University
Martti Ahtisaari Institute at Oulu Business School	University of Borås
Novia University of Applied Sciences	University of Gothenburg
Oulu university of applied sciences	University of Gävle
Saimaa University of Applied Sciences	University West
Satakunta University of Applied Sciences	Uppsala University
Savonia University of Applied Sciences	
Tampere University of Applied Sciences	*International universities*
Tampere University of Technology	Cornell University, USA
Turku University of Applied Sciences	Ghent University, Belgium
University of Eastern Finland	HFT Stuttgart, Germany
University of Helsinki	National University of Singapore
University of Tampere	University of Zagreb, Croatia
University of Turku	KEDGE Business School, France
Abo Akademi University	
	Other participated stakeholders
Iceland	Aalto University Properties Ltd, Finland
Bifrost University	CSR Västsverige, Sweden
Holar University College	Forum for Nature Protection, Norway
University of Iceland	Foundation for Environmental Education FEE, Norway
	Spire, youth organization for sustainable use of resources, Norway
Norway	Tvergastein/Centre for Development and the Environment, Norway
Norwegian School of Sport Sciences	The Nordic Council of Ministers, Denmark
Norwegian University of Life Science	NUAS, The Nordic Association of University Administrators, Norway
Norwegian University of Science and Technology	The UN—UNEP/GUPES (by video), Kenya
Norwegian University of Science and Technology NTNU	The Sustainability Literacy Test, SuLiTest, France

and the survey introduction letter presented the global background of the project, information on the UN Rio+20 process was successfully distributed to a wide Nordic university community.

4.2 Outcome of the Survey

4.2.1 Implementation of SD

According to the majority of the respondents, energy efficiency is the most important SD-related issue for the Nordic HEIs (Fig. 1). Research on sustainable solutions and recycling are almost as important. Campus accessibility, renewable energy and changing behavior are considered moderately important, whereas campus biodiversity and educating teachers in sustainability are among issues that are not urgent.

According to the results, the overall level of integrating SD is only moderate (Fig. 2). Only 3 % of the respondents saw that their institution has reached its own targets (5/5). However, 43 % of the respondents estimated that their institution was at an operational level (level 4/5), whereas 16 % considered their HEI was at a planning level (3/5). On the contrary, 13 % found their institution to be at a zero-level (1/5) and 25 % only in a starting stage (2/5). Furthermore, sustainability implementation in campus operations and teaching appeared as very modest (Fig. 2). However, the situation seemed to be better in campus operations (score 3,2) compared to teaching (score 2,8).

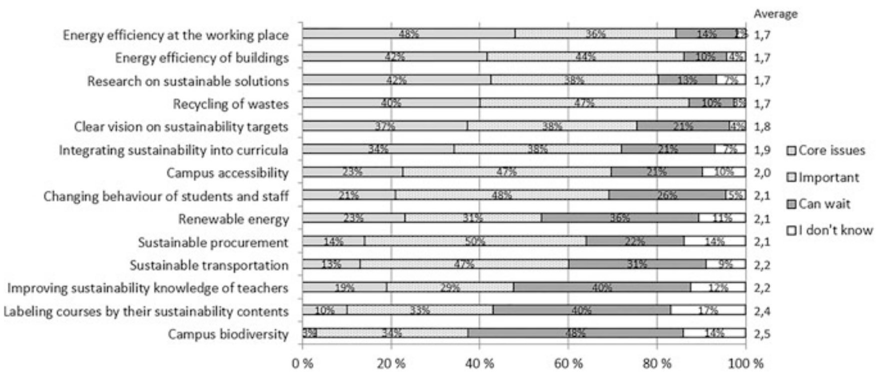


Fig. 1 The focus areas relating to SD (modified from Karvinen et al. 2015). Respondents (n = 152) evaluated the areas using a scale from 1 to 3, where: *1* core issue of my institution, *2* important for my institution, *3* not urgent and can wait for implementation ("Can wait"). I don't know-responses were excluded from averages

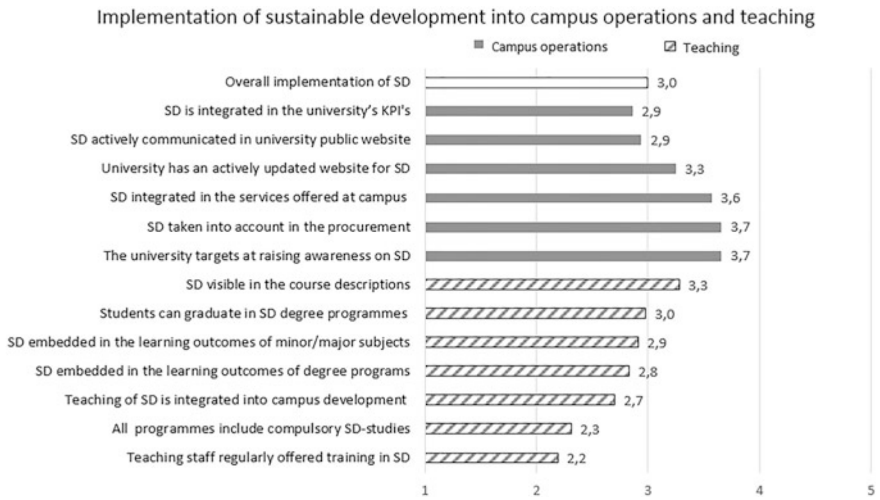


Fig. 2 Results from the survey: Scores based on survey respondents' evaluations on the implementation of SD in the Nordic HEIs (modified from Karvinen et al. 2015). Indicators measuring SD in teaching evaluated by teachers and environmental staff (n = 89) and indicators on campus operations' sustainability evaluated by administrational and environmental staff (n = 82). Evaluation scale: *1* entirely disagree, *2* mostly disagree, *3* do not agree or disagree, *4* mostly agree, *5* entirely agree. I don't know-responses were excluded from the scores. Overall implementation evaluated by all respondents (n = 152); scale: *1* not at all integrated, *2* starting stage, *3* planning stage, *4* operational stage, *5* have reached institution's targets

4.2.2 Key Drivers and Barriers in Implementing SD

The responses to open-ended questions gave a good picture on the views of the Nordic university staff (Fig. 3). According to them, policy and management-related issues both enable and hinder the implementation of SD, though management practices and organization seem to have a stronger hindering than enabling effect. Of all the respondents, 54 % recognized the lack of resources as a clear barrier.

Knowledge and attitudes seem to have a substantial effect on sustainability. The respondents indicated specifically the attitudes of decision-makers and an unsupportive attitude in general as factors preventing the implementation, whereas skilled and motivated staff were considered to drive sustainable actions. In addition, collaborative efforts, such as student involvement and projects, enable the implementation of SD, while the lack of collaboration between disciplines is hindering it.

Very similar measures were suggested to enhance the drivers and overcome the barriers (Fig. 4), particularly communications and awareness-raising. Furthermore, clarifying the strategy and targets related to SD, and having more resources were identified as important measures. About a third of the respondents called for more engaged and supportive leaders, and almost as many respondents suggested better educated staff as a means to overcome the barriers.

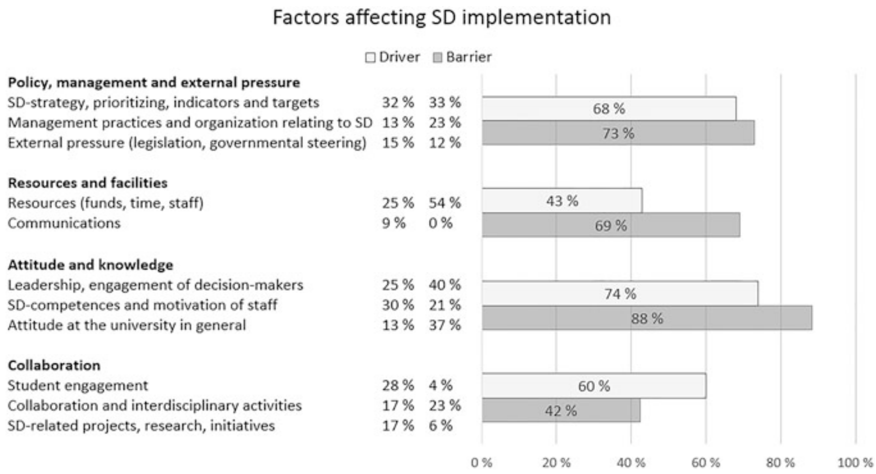


Fig. 3 Results from the survey: barriers and drivers affecting the implementation of SD in the Nordic HEIs (modified from Karvinen et al. 2015). The percentage of respondents (barriers n = 52, drivers n = 53) in the four main driver/barrier-categories (presented as *bars*), and the detailed classification under the main categories

Fig. 4 The suggestions of the respondents on how to enhance the drivers or overcome the barriers recognized in the previous question of the survey. N (enhance) = 55, n (overcome) = 46. (Modified from Karvinen et al. 2015)

4.3 Findings of the Copenhagen and Gothenburg Workshops

4.3.1 Implementation of SD

In the Copenhagen workshop, 48 % of the participants indicated operational level, 33 % a level between planning and operational, 5 % planning level and 14 % zero-level to be their institution's level of integrating SD. The result supports the findings of the survey.

In the Gothenburg workshop the main outcome was that indicators measuring ecological sustainability are more generally used than the ones measuring social sustainability. Furthermore, the participants recognized a need to develop better indicators for research and teaching, with easily accessible sustainability criteria for labelling of courses and programs by their SD contents. The workshop also resulted in a project plan to develop joint Nordic key word-list for searching SD-related research for reporting.

4.3.2 Drivers and Barriers to the Implementation of SD

The participants of the Copenhagen workshop identified numerous drivers and barriers, as well as means to enhance the drivers and overcome the barriers (Table 3). The most driving forces to sustainability were university-level and national-level SD-strategies, financial resources and EMSs. Better leadership, cost-benefit analyses and change in financial models were among suggested means to promote the drivers.

Unwillingness to change, university hierarchy, and lack of commitment and knowledge were the barriers that the working-groups mentioned most frequently, while incentives, top-down-processes and political cleverness were the most commonly suggested solutions to overcome these.

4.4 The Oslo Workshop

In the final workshop, the NSCN presented a new project on sustainability literacy of the Nordic students, which was developed based on the preliminary findings of the survey. The workshop participants set the goal for universities to lead the way and to reach 100 % sustainability. They also recognized severe challenges, including contradictory targets (e.g. CO_2-reduction and internationalization), lack of mandate to make changes, and lack of engaged leaders and resources. Finally, they suggested solutions for the Nordic HEIs to use the project results and to promote sustainable actions in:

1. Sharing and benchmarking
   - Sharing best practices recognized in the survey: for instance, Norway could be consulted in campus biodiversity and Sweden in ESD
   - More common guidelines and rankings for Nordic universities.

Table 3 Drivers and barriers identified in the Copenhagen workshop (five groups with 4–5 participants in each)

List of drivers and barriers identified in the Copenhagen workshop	
Drivers	**How to enhance the drivers**
Strategy of the university (4)	Better leadership (2)
National strategy for SD (3)	Cost-benefit anayses (2)
Financial and staff resources (3)	Change of financial model (2)
Environmental management system (3)	Connecting SD in campus operations and research (1)
Legislation (2)	Network of university members (1)
Other universities, role model (2)	Think tank (1)
Bottom-up processes (2)	Recognize how different individuals can contribute (1)
Benchmarking, best practices, rankings (2)	**Barriers**
Policy of the university (1)	Unwillingness to change, attitudes (3)
Will to implement SD (1)	Lack of commitment (2)
Mainstreaming, SD part of normal activities (1)	Lack of knowledge (2)
Internal network (1)	*Lack of resources (2)*
Informal connections within university (1)	Decentrialized, university hierarchy (1)
More people involved (1)	Too many other priorities (1)
Appoint faculties to SD (1)	Lack of leadership (1)
New programmes attracting students (1)	Lack of regulation (1)
Working life requirements (1)	Restructuring the organization, new management (1)
Circumstances and attitudes (1)	Faculty autonomy in operational areas (1)
Student voice (1)	**How to overcome the barriers**
Formal student democracy (1)	Incentives for SD-related education and research (2)
Staff & students activity (1)	Top-down approach (2)
Media (1)	Political cleverness (2)
Climate change (1)	Environmental management system (1)
Energy prices (1)	Open faculty positions with SD focus (1)
Waste and chemicals regulation (1)	Communications (1)
President's commitent (1)	Marketing (1)
Culture (1)	Values (1)

Number of groups that listed a certain driver/barrier is indicated in parentheses

2. Education

   – More obligatory courses on SD
   – More collaboration: courses mixing countries, disciplines and institutions
   – A Nordic certificate for sustainability education.

3. Student engagement

   – Universities should not wait for governmental steering, but act and let the students act
   – Bottom-up and top-down processes are both needed.

5 Discussion

Strategy emerged as one of the key drivers for sustainability in the project. However, it became clear that the implementation of SD strategies has succeeded only moderately, and the factors related to campus greening and ecological sustainability are more emphasized than SD in teaching or social sustainability. The finding is in line with a study of Aalborg University, Denmark: the focus is on administration rather than in education, research and outreach (Christensen et al. 2009). The bias to ecological sustainability may be explained by target-setting and indicators, which are commonly related to ecological factors, such as energy, CO_2 and paper consumption (Karvinen et al. 2015). According to Evangelinos and Jones (2009), such a lack of functional targets hinders the implementation of SD.

An interesting finding was, that although the institutions seem to target at raising awareness on SD, the respondents gave very modest estimations to SD-related communications. In fact, communications and interaction with the staff would be an efficient way to raise awareness (Sammalisto and Brorson 2008). Nordic university staff agrees with the earlier findings by Christensen et al. (2009) and Leal Filho (2011), stating that the attitudes and knowledge of decision-makers make a key barrier in the integration of SD. Therefore it would be of utmost importance to allocate resources to communications and training the staff.

However, it seems that the Nordic HEIs are allocating insufficient resources to train their teachers in sustainability, although limited teacher qualifications have been recognized to hinder the mainstreaming of ESD (Læssøe et al. 2009). On the contrary, in the survey conducted by Holm et al. (2014), 50 % of respondents evaluated that ESD competences are taught in faculties.

Establishing an EMS could lead to more structured and clearer organization, targets, and indicators. Karvinen et al. (2015) suggested, that the overall sustainability performance is at a higher level in Swedish HEIs compared to the HEIs in the other Nordic countries. The same trend was recognized between HEIs that had established an EMS according to ISO 14001, like 80 % of the Swedish HEIs responding to the survey. Sammalisto (2007) and Omrcen et al. (2013) argued that a certified EMS can function as an effective means to integrate SD in all university activities, including education. The regular audits required by a certified EMS keep the activities on the university agenda and provide opportunities for follow-up, feedback, and for further development.

6 Conclusions and Future Prospect

The Nordic project aimed at raising awareness on the UN Rio+20 process and higher education targets, and comprehending the approach of the Nordic HEIs to sustainability using the Rio+20 HESI initiative as a framework, addressing particularly campus operations and teaching. Furthermore, the project targeted at recognizing the key drivers and barriers in implementing sustainable development (SD). The project methods included a survey to the university staff and three interactive workshops.

The Nordic HEIs seem to be on their way in reaching the goals formulated in the Rio+20 WSSD (United Nations 2012) and Rio+20 HESI initiative (HESI 2012). However, there are still institutions that have yet to start the integration process, or are lacking proper targets, measures and commitment. Furthermore, the focus areas of SD seem to be in imbalance in the Nordic HEIs, campus greening activities being more emphasized than SD in teaching. In order to reach a balanced approach to sustainability, the targets and indicators measuring SD ought to be in balance, too. In addition, more attention should be paid to teachers' competences on SD to reach better levels of education for sustainable development (ESD). Integrating SD-related issues more efficiently in the institutions' communications, such as internal and external websites, would enhance awareness-raising.

Strategy emerged as a driving force for sustainability, but the evaluations on its implementation revealed that the strategy is either insufficient, unclear, or there are severe problems in realizing it in campus operations and teaching. According to the participants of the project, the implementation could be enhanced by both top-down and bottom-up approaches in the Nordic HEIs.

Four main conclusions to promote SD and to overcome the barriers came up. Firstly, if universities would be steered through legislation and financial, results-based incentives, the management could be more encouraged to support SD. Secondly, establishing an EMS could lead to a more structured and clearer organization of SD work. Thirdly, the Nordic HEIs should strive for more collaboration and sharing of experiences to reach better levels of sustainability. Increasing the amount of student engagement and inter- and multidisciplinary projects would raise awareness and change behavior throughout the institution. Finally, the visibility of SD and the mainstreaming of ESD could be promoted through better communications and educating the staff.

The results illustrate the fundamental need for an institutional approach to sustainability (Cortese 2003), in which deep commitment is required from the grassroots to the top management. Legislation is rarely in the hands of SD practitioners at universities, therefore each individual should be challenged to operate at the level most appropriate for them; staff members working with stakeholder relations and collaborating with governmental authorities might be more capable of affecting the governmental steering measures, while university teachers could activate the students and colleagues to create a culture of sustainability to the campus and promote the establishment of an EMS. Furthermore, since the number of drivers and barriers identified in the project was substantial, every HEI is encouraged to identify their own individual driving and hindering factors in order to find appropriate measures to enhance sustainability. Furthermore, collaboration and benchmarking among the HEIs from the same region, as well as internationally, is highly recommendable to recognize common barriers, and to share best practices.

This research was limited to discuss on campus operations and teaching, excluding the two other dimensions in the Rio+20 framework, namely research and outreach. Moreover, the participants of the project represent only a small proportion of the whole Nordic university community, and included mostly staff already interested in sustainability. Thus, the views of the participants may be biased in this respect. Additionally, the generalized indicators used in the survey were able to give only a direction of the approach to SD of the Nordic HEIs. Finally, detailed analyses ought to be made on perceptions of different respondent groups, such as teachers from different disciplines, and administration and environmental staff, which were excluded from the focus of this paper.

In the case of the Nordic HEIs, future studies should concentrate on investigating measures to commit the university leaders to institutional sustainability, and in reforming the indicators measuring SD. Furthermore, detailed information is needed on visualizing sustainability at the HEIs, and on SD-contents of learning outcomes of courses and programs. In order to develop the curricula, it would be highly beneficial to research how the Nordic teachers address sustainability in their courses, and what is the recent level of sustainability literacy of Nordic students.

The project succeeded in creating new connections that finally led to new project proposals on sustainability literacy and indicators. To conclude, an intensive project can be considered a successful means to strengthen the collaboration among university staff, and to recognize important sustainability aspects of the HEIs in a region.

References

Barth, M., & Rieckmann, M. (2012). Academic staff development as a catalyst for curriculum change towards education for sustainable development: An output perspective. *Journal of Cleaner Production, 26*, 28–36.

Cebrián, G., Grace, M., & Humphris, D. (2015). Academic staff engagement in education for sustainable development. *Journal of Cleaner Production, 106*, 79–86.

Chambers, D. (2009). Assessing and planning for environmental sustainability—A framework for institutions of higher education. In W. Leal Filho (Ed.), *Sustainability at universities—Opportunities, challenges and trends* (pp. 287–296). Frankfurt: Peter Lang.

Christensen, P., Thrane, M., Herrebor, Jørgensen T., & Lehmann, M. (2009). Sustainable development. Assessing the gap between preaching and practice at Aalborg University. *International Journal of Sustainability in Higher Education, 10*(1), 4–20.

Cortese, A. D. (2003). The critical role of higher education in creating a sustainable future. *Planning for Higher Education, 31*(3), 15–22.

Dahl, A. L. (2012). Achievements and gaps in indicators for sustainability. *Ecological Indicators, 17*, 14–19.

Eriksson, R., Nenonen, S., Nielsen, S., Junghans, A., & Lindahl, G. (2014). Sustainable retrofitting of Nordic University Campuses. *International Journal of Facilities Management,* 92–103.

European Commission. (2015). *Innovation union scoreboard 2015*. http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards/files/ius-2015_en.pdf (Last Accessed March 9, 2016).

Evangelinos, K. I., & Jones, N. (2009). An analysis of social capital and environmental management of higher education institutions. *International Journal of Sustainability in Higher Education, 1*(4), 334–342.

Ferrer-Balas, D., Adachi, J., Banas, S., Davidson, C. I., Hoshikoshi, A., Mishra, A., et al. (2008). An international comparative analysis of sustainability transformation across seven universities. *International Journal of Sustainability in Higher Education, 9*(3), 295–316.

HESI. (2012). *Higher education sustainability initiative*. https://sustainabledevelopment.un.org/sdinaction/hesi (Last Accessed January 30, 2016).

Holm, T., Sammalisto, K., Vuorisalo, T., & Grindsted, T. S. (2012). A model for enhancing education for sustainable development with management systems: Experiences from the Nordic countries. In W. Leal Filho (Ed.), *Sustainable development at universities: New Horizons* (pp. 261–272). Frankfurt am Main: Peter Lang Scientific Publishers.

Holm, T., Sammalisto, K., & Vuorisalo, T. (2014). Education for sustainable development and quality assurance in universities in China and the Nordic countries: A comparative study. *Journal of Cleaner Production, 107*, 529–537.

Holm, T., Sammalisto, K., Grindsted, T. S., & Vuorisalo, T. (2015). Process framework for identifying sustainability aspects in university curricula and integrating education for sustainable development. *Journal of Cleaner Production, 106*, 164–174.

Holmberg, J., Lundqvist, U., Svanström, M., & Arehag, M. (2012). The university and transformation towards sustainability: The strategy used at Chalmers University of Technology. *International Journal of Sustainability in Higher Education, 13*(3), 219–231.

Jones, P., Trier, C. J., & Richards, J. P. (2008). Embedding education for sustainable development in higher education: A case study examining common challenges and opportunities for undergraduate programmes. *International Journal of Educational Research, 47*(6), 341–350.

Karvinen, M., Löyttyniemi, M., Römpötti, E., Sandberg, T., Lundgren, U., Silde, J. B., et al. (2015). *Rio + 20 implementation in the Nordic HEIs: Survey report*. https://nordicsustainablecampusnetwork.files.wordpress.com/2015/11/nscn_rio20surveyreport_final_11_2015.pdf (Last accessed January 30, 2016).

Koester, R. J., Eflin, J., & Vann, J. (2006). Greening of the campus: a whole-systems approach. *Journal of Cleaner Production, 14*, 769–779.

Læssøe, J., Schnack, K., Breiting, S., & Rolls, S. (2009). *Climate change and sustainable development. The response from education: A cross-national report from International Alliance of Leading Education Institutes Danmarks Pædagogiske Universitetsskole*. Copenhagen: Aarhus Universitet.

Leal Filho, W. (2011). About the role of universities and their contribution to sustainable development. *Higher Education Policy, 24*, 427–438.

Lozano, R. (2006a). Incorporation and institutionalization of SD into universities: breaking through barriers to change. *Journal of Cleaner Production, 14*(9), 787–796.

Lozano, R. (2006b). A tool for a graphical assessment of sustainability in universities (GASU). *Journal of Cleaner Production, 14*(9–11), 963–972.

Lozano, R., & Peattie, K. (2009). Developing a tool to audit curricula contributions to sustainable development. In W. Leal Filho (Ed.), *Sustainability at universities—Opportunities, challenges and trends* (Umweltbildung, Umweltkommunikation und Nachhaltigkeit) (p. 31). Frankfurt am Main: Peter Lang Publishing Group.

Lozano, R., Lukman, R., Lozano, F. J., Huisingh, D., & Lambrechts, W. (2013). Declarations for sustainability in higher education: becoming better leaders, through addressing the university system. *Journal of Cleaner Production, 48*, 10–19.

Maassen, P., Vabø, A., & Stensaker, B. (2008). Translation of globalisation and regionalisation in Nordic cooperation in higher education. *Borderless Knowledge* (pp. 125–139). Netherlands: Springer.

Mcmillin, J., & Dyball, R. (2009). Developing a whole-of-university approach to educating for sustainability linking curriculum, research and sustainable campus operations. *Journal of Education for Sustainable Development, 3*(1), 55–64.

Nordic Council of Ministers. (2009). *Sustainable development—New bearings for the Nordic Countries*. Copenhagen: Scanprint A/S.

Nordic Council of Ministers. (2010). *Global pressure—Nordic solutions? The Nordic globalization barometer 2010*. Copenhagen: Scanprint A/S.

Nordic Council of Ministers. (2011). *Knowledge for green growth and welfare: The council of ministers for education and research's MR-U strategy for education and research 2011–2013*. Skive: Arco Grafisk A/S.

Nordic Council of Ministers. (2013). *A good life in a sustainable Nordic region: Nordic strategy for sustainable development*. Arco Grafisk A/S.

Omrcen, E., Lundgren, U., & Dalbro, M. (2013). Can an environmental management system be a driving force for sustainability in higher education? A case from the University of Gothenburg, Sweden. In A. König (Ed.), *Regenerative sustainable development of universities and cities* (pp. 88–106). UK and USA: Edward Elgar Publishing.

Ralph, M., & Stubbs, W. (2014). Integrating environmental sustainability into universities. *Higher Education, 67*(1), 71–90.

Ramos, T. B., Caeiro, S., van Hoof, B., Lozano, R., Huisingh, D., & Ceulemans, K. (2015). Experiences from the implementation of sustainable development in higher education institutions: Environmental Management for Sustainable Universities. *Journal of Cleaner Production, 106*, 3–10.

Roorda, N., & Martens, P. (2008). Assessment and certification of higher education for sustainable development. *Sustainability: the Journal of Record, 1*(1), 41–56.

Sammalisto, K. (2007). *Environmental management systems—A way towards sustainable development* (Universities Doctoral dissertation) The International Institute for Industrial Environmental Economics (IIIEE), Lund University, Sweden.

Sammalisto, K., & Brorson T. (2008). Training and communication in the implementation of environmental management systems (ISO 14001): A case study at the University of Gävle, Sweden. *Journal of Cleaner Production, 16*(3), 299–309.

Segalas, J., Ferrer-Balas, D., Svanström, M., Lundqvist, U., & Mulder, K. F. (2009). What has to be learnt for sustainability? A comparison of bachelor engineering education competences at three European universities. *Sustainability Science, 4*(1), 17–27.

Shriberg, M. (2002). Institutional assessment tools for sustainability in higher education: Strengths, weaknesses, and implications for practice and theory. *International Journal of Sustainability in Higher Education, 3*(3), 254–270.

Svanström, M., Lozano-García, F. J., & Rowe, D. (2008). Learning outcomes for sustainable development in higher education. *International Journal of Sustainability in Higher Education, 9*(3), 339–351.

UNEP, United Nations Environmental Program. (1972). *Declaration of the United Nations Conference on the Human Environment*. http://www.unep.org/Documents.Multilingual/Default.asp?documentid=97&articleid=1503 (Last Accessed January 30, 2016).

United Nations. (2006). *Decade of education for sustainable development*. http://unesdoc.unesco.org/images/0014/001486/148650E.pdf (Last accessed January 30, 2016).

United Nations. (2012). *The future we want*. http://www.un.org/en/sustainablefuture/index.shtml (Last accessed 1/30/2016).

United Nations. (2014). Global Action Program, http://unesdoc.unesco.org/images/0022/002243/224368e.pdf (Last Accessed January 30, 2016).

Velazquez, L., Munguia, N., & Sanchez, M. (2005). Deterring sustainability in higher education institutions: An appraisal of the factors which influence sustainability in higher education institutions. *International Journal of Sustainability in Higher Education, 6*(4), 383–391.

Wals, A. E. (2014). Sustainability in higher education in the context of the UN DESD: A review of learning and institutionalization processes. *Journal of Cleaner Production, 62*, 8–15.
Wright, T. S. A. (2002). Definitions and frameworks for environmental sustainability in higher education. *International Journal of Sustainability in Higher Education, 3*, 203–220.

Authors Biography

Meeri Karvinen has a M.Sc. in animal ecology from the University of Helsinki, Finland, where she also worked as a researcher in the field of urban ecology. Since 2013 she has worked as the coordinator of the Nordic Sustainable Campus Network at Aalto University, Finland. During 2014–2015 she was additionally the project manager of the network's Rio+20—related project. Karvinen is a doctoral candidate at Aalto University with a special research focus on sustainability and biodiversity contents of Nordic engineering education, and she additionally lectures on urban ecology and sustainable campuses.

Ullika Lundgren works as a sustainability controller at the University of Gothenburg, Sweden, and as an environmental coordinator at the Faculty of Science. She has a B.Sc. in marine biology from the University of Gothenburg and a wide experience on environmental management and audit, which she has also studied at University West, Sweden. She led the Tjärnö Marine Biological Laboratory to certificate according to ISO 14001, which was the first unit at the University of Gothenburg to reach this goal. Later on the whole university has been certified. Lundgren also teaches environmental management and environmental audit, and during 2012–2013 she was appointed technical expert in the Swedish Standards Institute Technical Committee for the international assignment to revise the standard ISO 14001.

Helena Mälkki has a M.Sc. (Tech.) degree in energy technology and a Lic.Sc. (Tech.) in energy and environment at Lappeenranta University of Technology, Finland. Since 2010 she has been working as a teaching researcher at Aalto University, Finland with a main focus on Life Cycle Assessment (LCA), Design for Environment (DFO), and developing problem-based learning (PBL) and sustainability contents of higher education. Previously, she worked as an educational manager in the Environmental Engineering degree program at Helsinki University of Technology, Finland. Before her university career, she worked as a senior research scientist in environmental research issues at VTT (Technical Research Centre of Finland).

Jaana Sorvari works as an associate professor in environmental engineering since August 2014. She graduated with a M.Sc. (Tech.) in chemical engineering from Helsinki University of Technology (HUT), where she also attained the Lic.Sc. (Tech.) degree in 1997 in the same field. She defended her doctoral thesis in the University of Oulu in 2010. From 1997 till 8/2014 she worked as an expert and senior research scientist in the Finnish Environment Institute (SYKE) where she planned, coordinated and implemented several projects dealing with the management of contaminated sites and recycling of mineral industrial wastes. Besides research projects and expertise tasks, she participated in the preparation of national legislation and guidelines and gave numerous invited lectures in Finnish universities. While risk analysis has been her main field of expertise, she is also familiar with life cycle analysis, multi-criteria decision analysis, and sustainability appraisal. Before SYKE she worked in as an environmental consultant, as a researcher in HUT, and as a part-time teacher in three different departments of HUT (from 1986 till 1994). Sorvari has published altogether 144 scientific and professional articles and conference papers, book chapters and reports.

Part II
Implementation Strategies

Energy Consumption in Student Hostels of Universiti Sains Malaysia: Energy Audit and Energy Efficiency Awareness

Theam Foo Ng, Ahmad Firdaus Ahmad Shabudin, Mohd Sayuti Hassan, Marlinah Muslim and Kamarulazizi Ibrahim

Abstract

Electricity is the main energy source consumed whereby our daily activities are predominantly and increasingly dependent on it. In the developing world where most countries steadily undergo rapid urbanization and population growth, energy consumption has immensely intensified over the last few decades. High energy demand is greatly propelled by consumption especially in residential, commercial, and university buildings. With the growing demands for electricity, increased costs of power and the desire to minimize dependence on energy generated by fossil fuels, initiative for efficient energy consumption particularly in building is given an increasing attention across the nation. Higher education is a growing sector with student numbers increasing every year. This means that the energy consumption of universities is also growing. This paper focuses on energy audit activities conducted in eight student hostel buildings of Universiti Sains Malaysia (USM) to assess the level of total energy consumption. Concurrently, the level of student engagement in sustainable energy consumption practices was evaluated. Furthermore, energy consumption for lighting in

T.F. Ng (✉) · A.F. Ahmad Shabudin · M.S. Hassan · M. Muslim · K. Ibrahim
Centre for Global Sustainability Studies, Universiti Sains Malaysia, Level 5, Hamzah Sendut Library (New Wing), 11800 Gelugor, Penang, Malaysia
e-mail: tfng@usm.my

A.F. Ahmad Shabudin
e-mail: as_firdaus@usm.my

M.S. Hassan
e-mail: sayuti@usm.my

M. Muslim
e-mail: marlinah_muslim@usm.my

K. Ibrahim
e-mail: kamarul@usm.my

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_12

each hostel was determined through a survey. The results garnered from the audit were evaluated and feasible alternatives for potential energy saving and conservation measures were consequently identified and recommended to improve energy efficiency in the buildings.

Keywords
Sustainability · Sustainable development · Education · Awareness · Electricity · Energy efficiency · Consumption · Audit · Student

1 Introduction

Sustainable energy is one of 17 Global Goals that make up the 2030 Agenda for Sustainable Development. In order to achieve this goal, energy consumption and energy efficiency are among key entities to control and monitor. Half of total world population (3.6 billion) live in urban areas and the United Nations Department of Economic and Social Affairs has projected the urban population to increase by 6.3 billion in 2050 (while the world population to increase by 9.3 billion) (UNDESA 2012). The Global Energy Statistical Yearbook (2014) reported that the consumption of domestic electricity worldwide is growing. Based on the report, China is the world's largest power consumer (4600 TWh), followed by the United States (3819 TWh), Japan (923 TWh), India (857 TWh) and Russia (856 TWh). Presently, the hike of electricity consumption in Malaysia is due to increased demand resulted from exponential population and economic growth (Sadrzadehrafiei et al. 2011; Tan et al. 2013). In reference to the Electricity Supply Industry in Malaysia-Performance and Statistical Information (2012) published by the Energy Commission of Malaysia, the demand of electricity has increased by 4.1 % from 104,220 GWh in 2011 to 108,473 GWh in 2012. Meanwhile, the sales of electricity had increased by 3.8 % from 93, 640 GWh in 2011 to 97,243 GWh in 2012.

According to the APEC Energy Demand and Supply Outlook-Fifth Edition published by The Asian Pacific Energy Research Centre (APERC) in 2013, carbon dioxide (CO_2) emission from fuel combustion for electricity generation was projected to reach 264 tons by 2035, making this sector the biggest CO_2 emitter (33 %). Therefore, alternative electricity generation from renewable energy sources which can potentially minimize the amount of carbon footprints, without compromising security of energy supply, is greatly demanding. Efforts in finding replacement for electricity generation using natural resources (fossil fuels) were intensified prior to high electricity consumption. These include current facility developments of hydroelectric power stations by Sarawak Corridor of Renewable Energy (SCORE) and other renewable energies (e.g. biomass and solar) by the Ministry of Natural Resources and Environment (APEC Energy Demand and Supply Outlook-Fifth Edition 2013). Due to imbalance of electricity supply and demand, austerity measures and actions for efficient electricity consumption must be implemented.

Since university buildings are high consumers of energy in the category of commercial buildings, many public universities in Malaysia have initiated energy management programs to materialize the call for better energy use (Saleh et al. 2015). The programs are in line with the efforts in advocating energy saving at all education centres by the Malaysian Ministry of Higher Education (MOHE) and the Malaysian Ministry of Education (MOE) (Wai et al. 2011). This includes carrying out an energy management list of practices to help the universities plan, review, benchmark and allocate resources better and focus on what would help achieve energy savings. This initiative is important because in general, all universities have large build up areas, comprehensive facilities as well as large numbers of building users.

In response to such programs, we were motivated to investigate and audit energy consumption in the main campus of Universiti Sains Malaysia (USM), one of the premier universities in Malaysia located close to Georgetown, Penang. Cost of electricity is undeniably the highest financial expense of USM whereby the daily consumption in the main campus alone amounts to over RM 20,000 (US$4882.99; €4458.14). The staggering figure indicates that immediate measures should be implemented to reduce expenses. USM authorities are striving to determine practicable measures to manage electricity consumption in the campus. Other than that, Sustainable Campus Secretariat of USM was established in 2000 aiming to nurture awareness on the importance of preservation and empower sustainable lifestyle among students. Among pragmatic measures undertaken by the secretariat concerning to electricity consumption include dissemination of information on energy saving actions via website besides campaigns and talks in the campus.

2 Literature Review

A better understanding on electricity usage situation can be achieved by conducting an energy audit. Energy audit plays significant part in managing energy expenses by determining areas of energy wastage so potentials and opportunities for energy conservation and savings can be identified for a given facility or building (Jayamaha 2007). According to Singh et al. (2012), there are three types of energy audit, namely, preliminary or walk through energy audit (the simplest type of audit conducted in short period of time which emphasises on main energy supplies and demands), general energy audit (a detailed expansion of preliminary audit) and detailed energy audit (strict and extensive energy audit action plan followed by the industry).

Energy audits (walk-through and comprehensive audits) were conducted at Madonna University Nigeria, Akpugo Campus by Utazi and Ezurike (2015) whereby energy usage pattern of the staff lodges and student hostels were scrutinized. The audit indicated majority (57 %) of the respondents were unaware of energy efficiency practices (e.g. use of incandescent light bulb, habits of not turning off lights when leaving a room), suggesting for more awareness development among students and resident staffs. Unachukwu (2010) reported observation of similar nature in an energy audit at student hostels and staff houses of University of Nigeria, Nsukka. Meanwhile, studies by Baskar et al. (2014) and Bansod et al. (2015) at respective educational institutions recommended several energy efficient initiatives in bid to reduce energy consumption especially in three categories, namely, lighting, ventilation and heating or cooling. Among the recommended energy saving measures are replacement of tube fluorescent light with compact fluorescent light (CFL), replacement of higher wattage CFL with lower wattage CFL, replacement of desktop of CRT monitor with LCD monitor, replacement of higher wattage ceiling fans with lower wattage but of good quality ceiling fan and likewise.

Kumar and Kaur (2013) presented several methodological approaches for energy saving based on detailed energy audit conducted at National Institute of Technology Harmirpur, India. In effort to improve energy performance, the audit identified that reduction of daily computers operating hours from 7 to 5 h by putting the computers on 2-h sleep mode could achieve annual energy conservation of nearly 37.5 kWh. Simple replacement of incandescent lamps with LED fixtures could potentially reduce cost by up to 95 %. Besides, they concluded that air conditioner as less economical since it consumed greater energy than ceiling mount fan for similar amount of heat dissipation. They suggested in detail that selection of fan size (diameter) and number of fans to install should be dependent on room size. In addition, installation of inexpensive devices; occupancy sensors, timers or photocells, aimed to reduce lighting expenses, were suggested. The devices could help achieve up to 40 % savings by automatically turning off lights in unoccupied areas.

Energy simulation software (Visual DOE 4.1) was employed in an energy audit on a student cafeteria at King Fahd University of Petroleum and Minerals, Saudi Arabia by Mohammed and Budaiwi (2013). The study assessed energy performance of the facility and with aid of the computer software, a base-case energy performance model was developed to predict and identify energy conservation strategy applicable to the building envelope and HVAC system design. Various strategies which include standards, single and combined energy conservation measures were identified. The employment of the strategies yielded potential combined savings of 27.4 %, proving them as practicable means for achieving significant energy savings and reduce energy consumption.

This paper displays a study on total energy consumption of hostel buildings (student's accommodation) in USM by conducting a preliminary energy audit to analyse and quantitatively evaluate current lighting usage situation (total energy consumption) among residents in a particular hostel. It also identifies cost-effective measures for energy efficiency management for lightings in every hostel room which later can be implemented for energy efficiency programs in USM to promote student engagement (awareness level) in maintaining sustainable environment.

3 Methodology

This study utilised a mixed mix-quantitative research approaches to determine the energy consumption in USM's hostels and students awareness on energy consumption and efficiency. This study is involving a multi-strategy research design with standard social science methods which are divided into two stages; preliminary audits and detailed lamp audit. The preliminary audit involved random survey of hostel residents whereas the detailed lamp audit was a further step from quantitative estimates. The data generated were calculated and various methods to establish energy efficiency management were identified. Proposals were then made for retrofits or replacements with consequent cost benefit analysis. The scope for this energy audit was conducted and limited to eight student hostels of USM main campus in Penang which are (i) *Restu*, (ii) *Saujana*, (iii) *Tekun*, (iv) *Indah Kembara*, (v) *Aman Damai*, (vi) *Fajar Harapan*, (vii) *Bakti Permai* and (viii) *Cahaya Gemilang*.

3.1 Total Energy Consumption of Each Hostel Buildings

3.1.1 Facility and Utility Data Analysis

Compilation of historical data of monthly energy consumption (utility bills) of each hostel over 7 months period, i.e. from January to July 2015 was carried out. The monthly utility bills were obtained from administrative office of respective hostels. The compiled data were useful to establish understanding on the previous characteristics and patterns of electricity use. Additionally, the data could serve as a reference for future comparison after the energy audit program is implemented.

Below is the formula used to interchange the rates of monthly energy consumption in kWh to Malaysian ringgit (RM);

$$\begin{aligned} &Rate\ of\ monthly\ energy\ consumption\ (kWh) \\ &\quad = Rate\ of\ monthly\ energy\ consumption\ (RM)/0.224^{*} \end{aligned}$$

*Electrical tariff for university is RM0.224 (US$0.055; €0.05)/kWh based on TNB (National Grid) Electricity Tariff C2.

3.2 Energy Consumption for Lighting in Each Hostel and the Level of Student Engagement in Sustainable Energy Consumption Practices

3.2.1 Field Questionnaires

The questionnaires survey has been conducted between September and November 2015 that were administered to the targeted residents (student population) of respective hostels. One hundred seventh three (173) numbers of respondents have been interviewed by using structured questionnaire survey. Using Close-Ended Question (Yes/No), the questionnaire was essentially constructed to identify current electricity usage trends (number of hours switching on lights) among students besides to measure their awareness and engagement level on sustainable energy consumption practices and electricity efficiency programs held on campus.

3.2.2 Walk Through Survey

A walk through survey was conducted to evaluate electrical use of each hostel. The survey determined occupancy estimates based on room numbers, types and quantity of lamp used in each hostel room, lamp usage in voltages and also electricity wastage. Based on the garnered data, estimates of daily electrical load or usage was analysed and calculated using the following formula based on lamp number and voltage.

Energy used in a hostel per day[1]

$$
\begin{aligned}
&= \%\ of\ students \times total\ number\ of\ students\ staying\ in\ the\ hostel \\
&\quad \times number\ of\ hours \times [(number\ of\ long\ fluorescent\ lamp(s) \\
&\quad\ used\ in\ a\ room\ by\ each\ student \times power\ needed) \\
&\quad + number\ of\ short\ fluorescent\ lamp(s)\ used\ in\ a\ room\ by\ each\ student \\
&\quad \times power\ needed)]
\end{aligned}
$$

Total energy used in USM hostels daily

$$
\begin{aligned}
&= Energy\ used\ in\ hostels\ (Restu + Saujana + Tekun + Aman\ Damai \\
&\quad + Indah\ Kembara + Bakti\ Permai + Cahaya\ Gemilang + Fajar\ Harapan)
\end{aligned}
$$

4 Results

4.1 Total Energy Consumption in Each Hostel Buildings

Total energy consumption varied among the student hostels, the data is visualized through graph in Fig. 1. Fluctuations of energy consumption rate were generally

[1]Assumptions

1. Each student in hostel room uses only one long and short fluorescent tubes except for the hostels Fajar Harapan, Restu, Saujana and Tekun where each student shares one long fluorescent tube. Due to this sharing, a weightage of 0.5 was assigned during the calculation of the energy usage for a fair comparison.
2. All rooms in the hostels are fully occupied by students.
3. Power that consumed by long and short fluorescent tubes are 36 and 18 W, respectively.

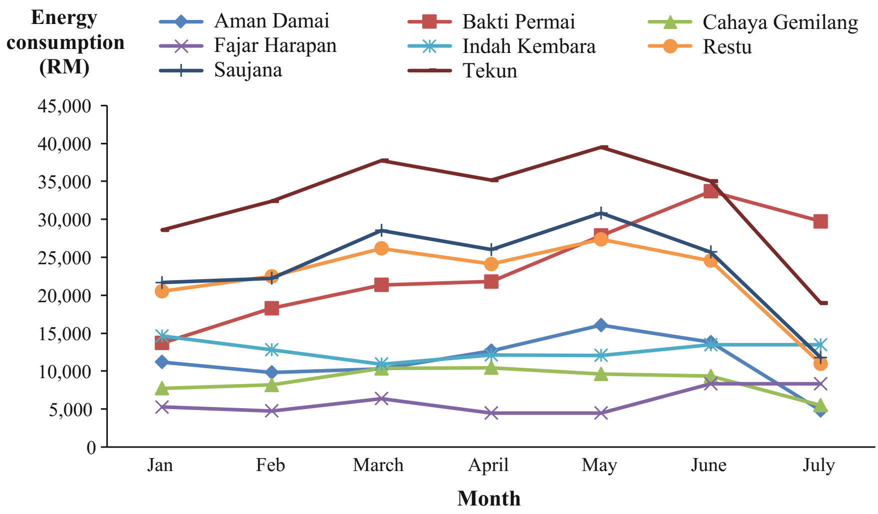


Fig. 1 Energy consumption of USM hostels from January to July 2015

observed from January to July in 2015 whereby the rate increased from January to March and decreased in April. Subsequently, the rate rose from May until June and declined again on July. Lower energy consumption in January, April and July was attributable to the absence of students during semester break.

There are several factors that contribute to total electricity consumption differences between the hostels. The factors can be divided into three categories; natural (e.g. occupant number, elevator usage), lifestyle (e.g. usage of prohibited electronic appliances, usage habits of the residents) and hostel rules enforcement (poor imposition of penalty).

Four hostels (Restu, Saujana, Tekun and Bakti Permai recorded significantly higher average electricity consumption rates compared to other hostels (Indah Kembara, Aman Damai, Fajar Harapan and Cahaya Gemilang) as shown in Fig. 2. The total average of electricity consumption rate in Tekun was significantly the highest (RM32479.71, US$7966.50, €7236.35). This was followed by Saujana, Bakti Permai, Restu, Indah Kembara, Aman Damai and Cahaya Gemilang; RM23823.37 (US$5843.31; €5309.20), RM23773.49 (US$5831.07; €5298.08), RM22301.85 (US$5470.11; €4968.77), RM12784.85 (US$3135.82; €2848.41), RM11243.67 (US$2757.80; €2505.96) and RM8737.31 (US$2143.05; €1947.35), respectively. Meanwhile, Fajar Harapan recorded significantly the lowest consumption rate of only RM6000.45 (US$1471.77; €1337.24).

Tekun recorded the highest average electricity consumption due to higher occupancy level with 2066 students (Fig. 3). The use of elevators at Tekun contributed to high electricity consumption as well. In addition, electricity at Tekun was not only supplied to residential buildings but also non-residential buildings which include a foyer, a flyover and a guard house. On the other hand, Fajar

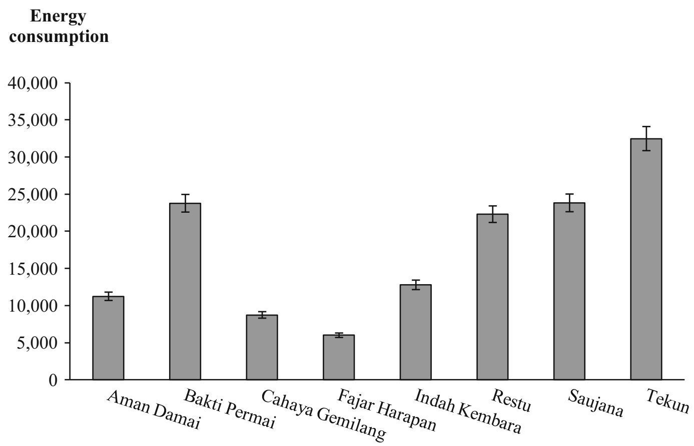


Fig. 2 Average energy consumption rates in each hostel. *Vertical lines* on each *bar* representing the standard error values. Means for each parameter followed by different *letters* were significantly different (Tukey's test, $p \leq 0.05$)

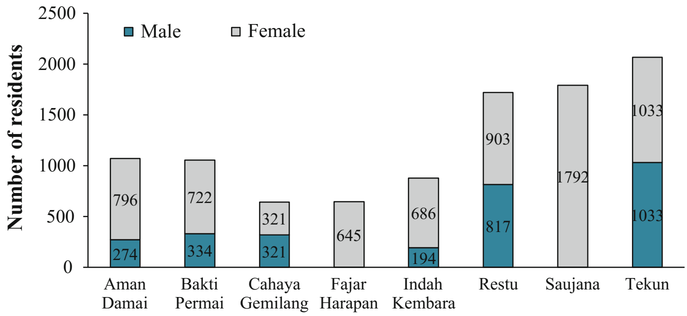


Fig. 3 Total numbers of residents in USM hostels

Harapan recorded the lowest electricity consumption due to low number of residents of only 645 students. Besides, the hostel was not equipped with energy consuming facilities like elevator. Based on the results in Fig. 3, the average total energy consumption at Bakti Permai was higher than Aman Damai even though the difference of residents' number was only 14. This situation was due to the presence of students during semester break.

The results in Fig. 4 showed the electricity consumption rate for a single resident in a month. On average, each resident in Bakti Permai consumed significantly the highest energy of RM22.51 (US$5.52; €5.02), followed by Tekun, Indah Kembara, Cahaya Gemilang, Saujana, Restu, Aman Damai with consumption rate of RM15.72 (US$3.86; €3.50), RM14.53 (US$3.56; €3.24), RM13.61 (US$3.34; €3.03), RM13.29 (US$3.26; €2.96), RM12.96 (US$3.18; €2.89), and RM10.51

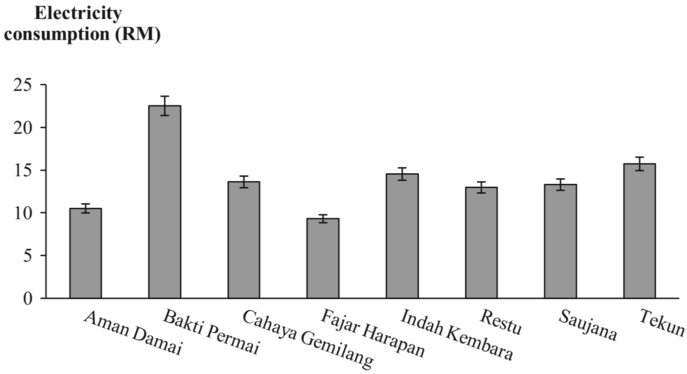


Fig. 4 Electricity consumption rate of each resident in each hostel. *Vertical lines* on each *bar* representing the standard error values. Means for each parameter followed by different *letters* were significantly different (Tukey's test, p $\leq$ 0.05)

(US$2.58; €2.34), respectively. Significantly, the lowest energy consumption rate per resident of only RM9.30 (US$2.28; €2.07) was recorded at Fajar Harapan.

4.2 Energy Consumption for Lighting in Each Hostel and Level of Student Engagement in Sustainable Energy Consumption Practices

The survey study involved random sampling from a student population. A total number of 173 respondents participated in the survey, comprising of 104 females (60 %) and 69 males (40 %). Twenty one out of 173 respondents were resided in Restu, Tekun, Bakti Permai and Cahaya Gemilang (Table 1). Meanwhile, distribution of the rest of respondents was as follows; Saujana (20), Aman Damai (30), Indah Kembara (23) and Fajar Harapan (16).

Majority of the respondents (68) stayed in the hostels for three years. In addition, there were 26 (15 %) respondents who stayed at hostel for one year while 48

Table 1 Distribution of respondents according to hostels

Hostel	Number of respondents
Restu	21
Saujana	20
Tekun	21
Indah Kembara	23
Aman Damai	30
Fajar Harapan	16
Bakti Permai	21
Cahaya Gemilang	21
Total	173

Table 2 Number of years staying at hostels

Number of years	Number of respondents
1	26
2	48
3	68
4	25
Others	6
Total	173

Table 3 Duration of lights usage

Duration of lights usage (h)	Number of respondents
1–4	24
4–8	84
8–12	39
12 and above	26
Total	173

(28 %) of them stayed for two years. On the other hand, 14 % of the respondents stayed for four years and another 3 % were categorized as others (Table 2).

Apparently, 84 % of the respondents switched on lights for 4–8 h daily (Table 3). Meanwhile, the number of respondents who switched on lights for 8–12 h, 12 h and above, and 1–4 h were 39, 26, and 24 respectively.

During the day (in the morning and at noon), 105 respondents did not switch on light (Table 4). Contrarily, 68 respondents acted the opposite way.

Based on Table 5, 61 respondents switched off light when leaving room to the toilet or pantry even for short time whereas 60 respondents behaved differently. In addition, 52 respondents switched off light occasionally. This result evidenced that majority of the respondents were unaware of the importance of electricity saving.

Table 4 Number of respondents switching on light in the morning and at noon

Switch on light in the morning and at noon	Number of respondents
No	105
Yes	68
Total	173

Table 5 Number of respondents switching off light when leaving room

Switch light off when leaving room	Number of respondents
No	60
Yes	61
Occasionally	52
Total	173

Table 6 Awareness on the Earth Hour campaign among respondents

Student awareness	Number of respondents
Yes	152
No	21
Total	173

Table 7 Number of respondents participated in the Earth Hour campaign

Student participation	Number of respondents
Yes	82
No	70
Total	152

Table 8 Duration of lights switched on at each hostel

Duration (h)	Number of respondents							
	Aman Damai	Bakti Permai	Tekun	Restu	Saujana	Indah Kembara	Fajar Harapan	Cahaya Gemilang
1–4	7	2	4	4	3	0	5	0
4–8	11	5	7	7	15	14	5	18
8–12	9	3	7	5	2	7	4	3
12 and above	3	11	3	5	0	2	2	0

With the reference to Table 6, 152 out of 173 respondents were aware of the Earth Hour campaign in USM campus while 21 respondents were not.

Most of them (82 respondents) participated in the Earth Hour campaign carried out in the campus while 70 respondents did not (Table 7).

The garnered data on student behaviour with regard to number of hours switching on lights was tabulated in Table 8. Using the data in Table 8 and by assuming the hostels are fully occupied, total daily energy consumption for each hostel were calculated and tabulated in Table 9. Poor energy consumption practice

Table 9 Total daily energy consumption of each hostel

Hostel	Total number of residents	kWh**
Aman Damai	1168	441.2
Bakti Permai	839	422.71
Tekun	2066	557.45
Restu	2066	575.29
Saujana	1864	394.23
Indah Kembara	916	382.85
Fajar Harapan	600	144.62
Cahaya Gemilang	1119	396.40
Total energy consumption		3314.75

**Total energy used for each hostel is calculated by assuming all hostel rooms were fully occupied of the residents was directly corresponding to high energy usage, as seen at Bakti Permai and Indah Kembara. Comparatively, the number of residents of Bakti Permai (839) was lower than that of Indah Kembara (916). However, daily energy consumption at Bakti Permai (433.71 kWh) was higher than Indah Kembara (382.85 kWh). Similar observation was noticed at Tekun and Restu when both hostels of similar number of residents recorded different daily energy consumption, i.e., the consumption at Restu was higher resulted by higher number of residents switching on lights for 12 h and above.

5 Discussion

5.1 Electricity Wastage

Student's habit of not switching off lights and fans was the main reason of electricity wastage. Similar finding was also reported by Unachukwu (2010) and Utazi and Ezurike (2015) in their study on student hostels and staff lodges in respective universities in Nigeria. This problem occurred largely due to their unawareness on the importance of electricity saving by which could be encouraged and inculcated among them through education, campaigns and talks. One way to reduce lighting usage at hostel is by taking advantage of natural daylight as source of illumination.

5.2 Earth Hour

Earth Hour, a campaign developed and run by the World Wildlife Fund (WWF), was launched in 2007 in Sydney, Australia. In five years, the campaign went global with participation of 152 countries and over 6895 towns, cities and municipalities (Sison 2013). Malaysia joined the Earth Hour campaign through its representative, the World Wildlife Foundation for Nature Malaysia (WWF-Malaysia). On March 2014, 'Friday Earth Hour', a campaign coordinated by the USM Green Campus Secretariat was launched. The one-hour campaign held weekly on Friday night from 9 to 10 pm aims to educate and enlighten the university community especially the students on the role of protecting the environment for future sustainability and human well-being (Rahman 2014).

Based on calculation, weekly saving of about 36 Wh per student was projected (assuming students use only one long fluorescent lamp). In one year, a considerable saving of 1873 Wh [36 Wh $\times$ 52 (Fridays per year)] will be attained. Evidently, significant reduction of energy consumption could be achieved if full cooperation is given by the students. Nonetheless, 12 % of the students were unaware of the campaign while 46 % of them who aware failed to participate. Hence, the university authority should reach out to more students by organizing supplementary campaigns and talks to foster awareness on energy saving and encourage or oblige them to participate in this event. On the other aspect, offering a subject on sustainable energy usage could be a useful educational instrument for students.

5.3 Light Emitting Diode (LED) as Replacement for Fluorescent Lamp

One of the disadvantages of fluorescent lamp is the reduction of lamp lifespan prior to frequent on-and-off switching. Under extreme conditions, the lifespan may be shorter than an economic incandescent lamp. Besides that, fluorescent lamp contains certain amount of mercury which may be released to the environment when broken. Around 99 % of the mercury is typically contained in the phosphor, especially on lamps that are near the end of life span. Mercury, a potentially toxic metal which is harmful when in contact with skin, inhaled or ingested. Mercury-containing fluorescent lamps are considered as hazard, making the disposal process complicated (Pandey et al. 2012). Hence, a safe and effective recycle system is needed for the lamp disposal. Apart from that, studies have shown that fluorescent lamps emit small amount of UV light which may pose various health problems (e.g. UV-related eye disease) to highly sensitive persons (Walls et al. 2011). Issues on disposal and recycling may arise from the fluorescent lamp contaminants. Disposal of phosphor and toxic mercury in particular is an environmental issue. In some countries, governmental regulations require special or separate disposal of fluorescent lamps from general and household wastes, which can be a fine example for application in Malaysia.

The advantages of LED lighting include lower maintenance cost, less environmental impact, speedy illumination, less energy consumption and higher durability (Thapa et al. 2014). Although the installation cost for LED lighting is more expensive than fluorescent tube, the potential savings it provides in long term is substantial. Ramya and Femina (2014) stated that fluorescent light can last up to 12,000 h while LED light can last up to 50,000 h (in the lifespan of one LED, 42 fluorescent tube are used). Since LED lighting provides longer lifespan, the maintenance and replacement frequency of lighting can be remarkably reduced (Soni and Devendra 2008). Furthermore, LEDs are completely safe and do not contain hazardous materials like mercury.

Other than that, LEDs provide instant and full illumination. Besides that, LED lightings also consume less power than fluorescent tubes. Even though fluorescent tube is considered as energy saving light sources compared to incandescent bulbs, it consumes more energy compared to LED. Comparatively, energy consumed by fluorescent tube for 1 h is equal to the energy consumed by LED for 8 h (Ramya and Femina 2014). LEDs are durable as they are not made of glass and are hollow inside. It is less likely to be inoperable due to breakage and thus removes the dangers of broken glass in such circumstances as well.

5.4 LED Motion Sensor Light

In present study, the results indicated that 30 % of the students did not switch off the light when leaving room whereas 35 % of them occasionally switch the light off. Comprehending the situation, LED motion sensor light could be an excellent alternative to reduce energy wastage in USM hostels because the technology is very efficient in eliminating the eventuality of leaving the light on by mistake (Lamba and Sanghi 2015). According to Kumar and Kaur (2013), an average of 128 h of unneeded lighting will be prevented lowering 10 % of energy consumption for lighting. Furthermore, LED motion sensor lighting which required no-switch system, are inexpensive and very practical to be set up or installed anywhere in the hostel. The motion sensor is very reliable and sensitive because it uses body heat and wave lengths to initiate illumination, thus giving convenience to users (Kwon et al. 2014).

6 Conclusion and Recommendations

Most of the energy expenditures and consumptions on hostel campuses in higher education occur within buildings for heating, cooling and lighting. Students residing in the campus hostel have a great deal of control over energy consumption such as lighting, fans, dryer, etc. Total energy consumption in each USM hostel buildings was closely related to the availability of residential and non-residential buildings, facilities (e.g., elevator) and number of residents. Besides that, high energy consumption in the hostels was directly corresponding to poor energy usage practices of the students as observed in Bakti Permai and Restu, resulted by students' behaviors that tend to leave room with lights on and prolong use of electricity for lighting (12 h and above). University hostel sustainability can be challenging because the students do not have a direct financial interest in energy conservation. Our study reveals that the level of student engagement in sustainable energy consumption practices was still moderate. The students' behaviour can have significant impacts on energy conservation and energy efficiency. Although 152 respondents stated that they were informed of the Earth Hour campaign, only 54 % took part in the event while the rest failed to do the same.

Therefore, supplementary efforts through Education for Sustainable Development (ESD) programme education are instrumental and key strategy to promote awareness, attitudes and behavioural changes toward energy consumption and reduction among students. ESD is an educational means instrumental to establish citizenship values into society via behavioural change using, social, environmental and cultural elements. Nonetheless, ESD should not be exclusively targeted to education system but government institutions and society as well. ESD programme and activities will empower the university students to take informed decisions and responsible actions for the sustainable consumption of energy resources and other sustainability issues.

Within this context, USM has initiated pedagogy and learning environments on sustainability and sustainable development in order to empower and mobilize its students through the establishment of an elective sustainability course WSU 101 (Sustainability: Issues, Challenges and Prospects) and *Sekretariat Kampus Sejahtera* (Campus Well-being Secretariat) (SKS). WSU 101 course is for the undergraduate students that emphasize the implementation of sustainable development through the study of global cases and examples drawn from sustainability program from around the world. At the end of the course, students are expected to demonstrate their level of sustainability understanding through group projects. Meanwhile, SKS became one of the platforms to instill volunteerism in students and support sustainability related activities on campus. SKS is now the major vehicle through which all sustainability-led campus or campus sustainability activities are carried out, it is headed by relatively young enthusiasts at the Vice Chancellors office. There are six clusters of SKS, namely energy efficiency, water conservation, biodiversity, healthy lifestyles, urban agriculture and waste management. It is a hope that these USM initiatives will give guidance to student community in terms of their commitment and responsibility toward the campus sustainability development through self-initiative, proactive team work and volunteerism, not only for energy consumption issues, but also for the whole issues of sustainability especially that highlighted in Sustainable Development Goal.

This research is among pioneer studies on the issue of the energy consumption and perceived awareness in university Campus residents that focusing on students. In general, this study will advance scholarly understanding of the present landscape of energy consumption in university and awareness of university students regards to energy efficiency. From a pragmatic perspective, the findings from this research will assist university management and governance to understand more about the level of energy consumption and to understand the awareness level of student on energy awareness and attitudes toward energy conservation. This will ultimately assist them to inaugurate new initiatives to confront the challenges on issues in energy consumption in university. Besides, the result may provide impetus to integrate the decision making process of university ESD strategy with national and international sustainable energy agendas. Lastly, it is hoped that the present study will serve as a reference other university to establish an approach of M and E (monitoring and evaluating) to measure the sustainable energy consumption in university building and community, as well as to design an adequate awareness programme to strengthen the student participation pertaining to the energy sustainable goal.

Acknowledgments The authors wish to thank the students of WSU101 course for their assistance in survey and secondary data collection. This research was supported by the Universiti Sains Malaysia's Research University Individual (RUI) Grant with account number 1001/PCGSS/816265.

References

Asia-Pacific Economic Cooperation (APEC) Energy Demand and Supply Outlook Fifth Edition. (2013). Asia Pacific Energy Research Centre, Japan.

Baskar, R. H., Mittal, H., Narkhede, M. S., & Chatterji, S. (2014). Energy audit—A case study. *International Journal of Emerging Technology and Advanced Engineering, 4*(3), 73–78.

Bansod, D., Jain, P., & Gour, A. (2015). Energy audit of university polytechnic of RGPV & boys hostel I. *International Journal of Advanced Research in Computer Science & Technology, 3* (2), 48–52.

Electricity Supply Industry in Malaysia-Performance and Statistical Information. (2012). Energy Commission of Malaysia.

Global Energy Statistical Yearbook. (2014). Enerdata.

Jayamaha, L. (2007). Energy-efficient building systems. McGraw-Hill.

Kumar, S., & Kaur, T. (2013). Energy audit: A case study. *International Journal of Research in Management, Science & Technology, 1*(1), 28–32.

Kwon, S.-Y., Im, K.-I., & Lim, J.-H. (2014). LED context lighting system in residential areas. *The Scientific World Journal, 2014*.

Lamba, M. K., & Sanghi, A. (2015). Energy audit on academic building. *International Journal of Engineering Research and General Science, 3*(4).

Mohammed, M. A., & Budaiwi, I. M. (2013). Strategies for reducing energy consumption in a student cafeteria in a hot-humid climate: A case study. *Journal of Sustainable Development of Energy, Water and Environment Systems, 1*(1), 14–26.

Pandey, S., Hooda, R., & Mishra, A. (2012). Proposed plan for disposal of mercury-bearing lamps for India. In B. Bilitewski, R. M. Darbra, D. Barceló (Eds.), *Global risk-based management of chemical additives II: Risk-based assessment and management strategies* (Vol. 23, pp. 419–440). Springer.

Rahman. (2014, April 22). *USM Earth Hour 2014 boosts 4000 participants*. Berita Kampus. Retrieved from http://www.beritakampus.usm.my/index.php/berita/sekitar-kampus/1109-usm-earth-hour-2014-boosts-4-000-participants

Ramya, L. N., & Femina, M. A. (2014). Energy auditing a walk-through survey. *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, 3* (2), 2320–3765.

Sadrzadehrafiei, S., Sopian, K., Mat, S., & Lim, C. (2011). Energy consumption and energy saving in Malaysian office buildings. Models and methods in Applied sciences. In N. Mastorakis, M. Demiralp, & N. A. Baykara (Eds.), *Proceedings of the International Conference on Environment, Economics, Energy, Devices, Systems, Communications, Computers, Mathematics*. IAASAT Press.

Saleh, A. A., Mohammed, A. H., & Abdullah, M. N. (2015). Critical success factors for successful energy management implementation towards sustainability in Malaysian Universities. *World Academy of Science, Engineering and Technology International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering, 9*(3), 740–748.

Singh, M., Singh, G., & Singh, H. (2012). Energy audit: A case study to reduce lighting cost. *Asian Journal of Computer Science and Information Technology, 2*(5), 119–122.

Sison, M. D. (2013). Creative strategic communications: A case study of Earth Hour. *International Journal of Strategic Communication, 7*(4), 227–240.

Soni, N. B., & Devendra, P. (2008). The transition to led illumination: A case study on energy conservation. *Journal of Theoretical and Applied Information Technology*, 1083–1087.

Tan, C. S., Maragatham. K., & Leong, Y. P. (2013). Energy outlook in Malaysia. In *4th International Conference on Energy and Environment 2013 (ICEE 2013)*. IOP Publishing. IOP Conf. Series: Earth and Environmental Science 16.

Thapa, B., Bista, D., & Basnet, S. (2014). Benefits and opportunity of new technology of lighting with reference to case study of Kathmandu University. *Dhulikhel. Rentech. Symposium Compendium, 4*, 47–52.

Unachukwu, G. O. (2010). Energy savings opportunities at the University of Nigeria, Nsukka. *Journal of Energy in Southern Africa, 21*(1), 1–10.
United Nations Department of Economic and Social Affairs (UNDESA). (2012). *World urbanization prospects, the 2011 revision*. New York, NY: United Nations.
Utazi, D. N., Ezurike, B. O. (2015). Energy audit of Madonna University Akpugo Campus. *International Journal of Scientific Research in Information Systems and Engineering, 1*(2).
Wai, C. W., Abdul Hakim Mohammed, A. H., & Low Sheau Ting, L. S. (2011). Energy management key practices: A proposed list for Malaysian universities. *International Journal of Energy and Environment, 2*(4), 749–760.
Walls, H. L., Walls, K. L., & Benke, G. (2011). Eye disease resulting from increased use of fluorescent lighting as a climate change mitigation strategy. *American Journal of Public Health, 101*(12), 2222–2225.

Author Biographies

Theam Foo Ng is a senior lecturer at the Centre for Global Sustainability Studies (CGSS), Universiti Sains Malaysia, Penang. His research interest is in the area of education for sustainable development, disaster risk management, machine learning, pattern recognition, computational intelligence, and mathematics.

Ahmad Firdaus Ahmad Shabudin is a research officer at the Centre for Global Sustainability Studies (CGSS), Universiti Sains Malaysia, Penang. His research interest is in SD, ESD, climate change, disaster risk management, and polar regions studies. His current responsibilities include research, publication, event organising and outreach programme.

Mohd Sayuti Hassan is a senior lecturer at the Centre for Global Sustainability Studies (CGSS), Universiti Sains Malaysia, Penang. His expertise is in tourism, logical framework analysis (LFA) and sustainability assessment methodology.

Marlinah Muslim is a research officer at the Centre for Global Sustainable Studies (CGSS), Universiti Sains Malaysia, Penang. Her expertise is in forestry sciences, sustainable development, safety and health for forestry management. Her current responsibilities include research, publication, and networking in South East Asia Sustainability Network (SEASN).

Kamarulazizi Ibrahim is the Director of Centre for Global Sustainability Studies (CGSS) and the founder Director of Centre for Education, Training, and Research in Renewable Energy, Energy Efficiency and Green Technology (CETREE) and Institute of Nano Optoelectronics Research and Technology (INOR). He is an expert in sustainable development, disaster risk management, semiconductor, energy and nano-technology. He has published several papers which emphasize on sustainability development goals such as Development with a Difference, Financing for Sustainable Development and A New Framework for Integrated Climate Finance and Inclusive Responses to Sustainable Development.

Resilience Thinking in Higher Education: Institutional Resilience as a Sustainability Goal

P. Brian Fisher

Abstract

Institutions are a primary vehicle for realizing sustainable development and sustainability. As part of scaling sustainability, resilience should be an institutional goal for any institution that is connected within various systems of support. For institutions of higher education, where there is an increased emphasis on sustainability, it is vital to consider the role of resilience as a foundational element of sustainability thinking. This article analyzes institutional resilience in a higher education setting within a sustainability context. Specifically, the article explores various ways to increase the institution's ability to cope with, and ultimately grow from, stressors and shocks from its environment. Within the article, a conceptual framework is designed to enhance institutional value as a pathway to sustainable development. This analysis will be relevant to global institutions of higher education, where the educational mission is threatened by a changing landscape that includes greater financial pressures, environmental challenges, and social fragmentation.

Keywords

Resilience · Sustainability · Higher education · Organizational learning · Adaptability · Interconnectivity

P. Brian Fisher (✉)
College of Charleston, Charleston, USA
e-mail: FisherB@cofc.edu

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_13

1 Introduction

The exploitative consequences from our current economic, ecological and social systems have become clear and with the potential for cascading crises (Meadows et al. 2005; Homer-Dixon 2012). Complicating matters, systems at every scale have become more complex. This complexity, while not undesirable itself, has deepened largely without adjustment. This complexity has given rise to emergent phenomenon that creates vast uncertainty and turbulence at all scales (Homer-Dixon 2012). That is, spontaneous, unpredictable emerging behavior can create a shock or crisis within a system virtually overnight. From an institutional perspective, this uncertainty and emergent (often non-linear) phenomena generates increasing systems' complexity that, in turn, leads to institutions that are "steadily more complex to produce good solutions" (Homer-Dixon 2012).

From an institutional perspective, operating in this environment results, quite naturally, in increasing structural complexity and solutions that are more complex. Even adaptive complexity can lead—without effective reorganization, to intricate bureaucracy and gross institutional inefficiencies. Much like natural and economic systems, pure growth in an increasing complex system has significant limits that can produce pernicious and often undesirable consequences. Moreover, as emergent behavior and cascading effects of an interconnected system prevail, predictive models for financial and organizational planning become less reliable and can compound the stresses.

Sustainable Development (SD) has emerged as a holistic paradigm to address these systems' design flaws, and to some degree, its deepening uncertainty and complexity. The idea is that human systems can continue to develop without diminishing other forms of capital (e.g. social, ecological, cultural, etc.) while constantly adapting to this shifting landscape. The desired by-product is prosperity through restoration rather than exploitation. Sustainability thinking undergirds SD and stresses that the key to rethinking our problematic designs is by understanding that our systems are holistic and interconnected, which requires diverse and integrated thinking (Sterling et al. 2013). In many ways, this shifts the traditional 3 R's of environmentalism to deeper elements of rethinking, redesign and restoration.

Part of this rethinking encouraged by sustainability is to consider the importance of institutions as vehicle for operationalizing the thinking behind it. Institutions represent one critical way to think of addressing these challenges *at scale*. That is, not only do institutions matter (Senge 2006), but because of their scalability and influence, they are a critical pathway for SD in addressing these complex, nonlinear problems. As such, they can become a vehicle for larger social change. Naturally, this leads to considering how institutions can utilize sustainability thinking *within* their organization—both as an end itself, but also to engender sustainability in the broader community and within their value chains.

Sustainability thinking has continued to evolve where it now challenges the fundamental way we see problems and attempts to address their root cause. Today, therefore, this thinking is taking a turn from efficiency improvements and reducing footprints to more holistic, integrated thinking that deepens the platform for redesign and restoration. It is beginning to drive at creating systems that can live up to the definition of sustainability: to perpetually endure while ensuring diversity and equity. In the midst of this evolution, the additional challenge for Higher Education institutions (HEIs) is that they possess the responsibility of not only honing a collective social conscience but to operationalize it in a way that positively affects the community while also helping students to actualize their personal values within that context. As scholars like Sterling et al. (2013) have noted, this makes HEIs a necessary vehicle for achieving SD and necessary social change.

One foundational element of any sustainable system is resilience. Resilience thinking has been championed for some time in a variety of contexts (Holling 1996; Everyly 2011; Folke 2006; Handmer and Dovers 1996), and even applied to organizations with some clear success in building more effective and robust organizations (see Handmer and Dovers 1996). This article explores institutional resilience as a goal toward sustainability and larger societal transformation. Within it, the role of institutional resilience is analyzed, along with what it means, and how HEIs can enhance resilience thinking as a guide for sustainability.

2 Situating Sustainability in HEIs

HEIs are considered key stakeholders and innovators within the field of sustainability and as a driver of sustainable development (Cortese 2003). Many HEIs have become model organizations for constant improvement toward meeting sustainability goals and objectives (Ferrer-Balas et al. 2008). However, these institutions suffer under similar stress points as any other organization—increasing uncertainty, social fragmentation, declining value, shifting priorities, expanding demands, and declining social and financial support. In many ways, and particularly for public institutions, global HEIs face increasing demands for their services, with declining support and while also meeting the challenges of a rapidly changing world.

This means, like many institutions challenged with operating in a shifting and turbulent environment, they cannot just talk about being sustainable in classrooms, they must actually do it. So, we see the sustainability challenge on three important fronts, one the "global higher education system as a whole remains maladaptive to the conditions we face" (Sterling et al. 2013), two that HEIs must also adapt and preserve operationally to be sustainable, especially in a globally competitive environment, and third that HEIs are part of greater support systems and communities in which they are embedded, meaning they cannot be sustainable in isolation. Sustainability, therefore, becomes an extremely important vehicle for not only addressing larger societal issues, but for learning how to operate pragmatically and responsibly within interconnected systems, at scale, and over time.

The expansion along these fronts has forced sustainability scholars and practitioners within HEIs beyond measures and projects based on eco-efficiency and renewable energy (Korhonen and Seager 2008). In fact, eco-efficiency approaches can undermine equity and adaptability—two hallmarks of sustainability (Korhonen and Seager 2008). Today, sustainability has come to represent a holistic paradigm that includes financial, social, cultural, and personal aspects of human and ecological well-being (Wright 2002; Barnard and Van der Merwe 2016). For example, AASHE (Association for the Advancement of Sustainability in Higher Ed) defines sustainability now far beyond the "green" world that a decade ago was the primary aspect to one today that focuses on "human and ecological health, social justice, [and] secure livelihoods" (AASHE 2016). Campus sustainability now includes food footprints, curriculum integration, associational and cultural life, community service, and the inherent equity and/or quality of life on the campus. This evolution comes at a critical time when buy-into sustainability programming has reached climax of sorts, where administrators are asking for more than just cost-cutting; they are increasingly asking to enhance *value* across the breadth of the HEI.

As this suggests, HEIs are increasingly expanding the temporal and spatial responsibilities to extend to future generations, a broader range of commitments, and into the larger community. These more expansive and longer-term social and environmental commitments have been empirically shown to contribute directly to organizational resilience and therefore more "sustainable" with higher rates of survival (Ortiz-de-Mandojana and Bansal 2015). As a result, campus sustainability is changing our understanding of the organization itself, how it operates within larger systems, its responsibility within those systems (to minimize exploitation), and ultimately to rethink and redesign those systems with a greater role in the advancement of SD.

3 Situating Resilience in HEIs Toward Sustainability

The critical measure for any institution is *value*—whether value is measured by the quality of educational output in an HEI or net worth in corporate setting. Vulnerability in a hyper-changing environment is inherently a threat to value. Underlying resilience thinking is that change occurs in all systems, and to ignore those inevitable changes increases vulnerability and therefore value (Walker and Salt 2006; Kayes 2015). Resilience, whether within higher education, corporate, or nonprofit organizations necessitate growth as an outcome from addressing constant change (Seligman 2011). Therefore, how that vulnerability is addressed provides critical insight into how far down the path an institution is to being resilient. In the end, organizational value is increasingly defined by how and to what degree the institution can adapt and grow than by an original mission statement or vision.

For an HEI, there is little that could be more important than building trust with the public, which is critical for attracting intellectual capital and students. As the new normal of constant turbulence and uncertainty is coupled with rising costs of education, that trust is in tenuous balance. As systems' unsustainability has become clearer new thinking and new ways to create institutional value are required to meet those challenges. Early on, sustainability practitioners and scholars leveraged this opportunity through eco-efficiency to combine saving financial resources with environmental protection. As sustainability broadened, resilience thinking helped to align those broader metrics and longer-range goals to generate additional value.

Resilience within ecology is defined as the ability to absorb disruptions while maintaining basic function and structure (Holling 1996; Walker and Salt 2006). Social resilience requires more than responding to one time shocks, and therefore it necessitates the ability to anticipatorily adjust to persistent change (Folke 2006). Resilience within an organization is usually characterized by the ability to correct maladaptive tendencies and positively adapt to those stressors (Ortiz-de-Mandojana and Bansal 2015). More technically it is the ability to recognize and respond to environmental signals and apply flexible resources interchangeable to meet the signaled challenges (Ortiz-de-Mandojana and Bansal 2015). Resilience toward sustainability—the ability to perpetually endure, suggests that *growth* must emerge from that adaptation. In other words, to perpetually endure requires not only constant adaptation, but it requires learning through that process to encourage new growth. Much like social resilience, the growth must account for diversity and equity in its distribution—otherwise, it can represent disruptions and negative feedback stressors.

In 1996, Handmer and Dovers created a typology of resilience. They argued that there were three types of resilience: Type 1 was resistance or inability to change, Type 2 was change at the margins that address the symptoms of issues, and Type 3 was an open and flexible process that addresses the cause of issues (Handmer and Dovers 1996). Expanding upon that framework within a sustainability context, organizational resilience can be classified as status quo, adaptive resilience, and resilience toward sustainability. For Handmer and Dovers, resilience could technically include entities resistant or with the inability to change. From an organizational perspective, it is difficult to recognize this except as an outlier phenomenon (i.e. an organization usually fails if it cannot adapt).

Handmer and Dovers (1996) distinguish between reactive and proactive resilience which is also instructive. This helps nuance simple adaptive measures from proactive ones. Proactive resilience is therefore the capacity to learn through and from adaptation that generates resilience on a path toward sustainability. In an organization sense, learning and adaptation become central to resilience (Kayes 2015). Today, "disruptions to organizations—such as budget cuts, natural disasters, disruptive technologies, emerging environmental policy, and persistent resource depletion—organizations need to not only absorb these disruptions, but they also need to grow from them" (Moran and Tame 2012). So, resilience in a sustainability context is the ability not only to bounce back, but also to learn through that process in ways that enhance the vitality and prosperity of the entity (Kayes 2015) through strategic growth opportunities. It requires therefore an elastic institution that can apply lessons learned from challenges, mistakes and/or successes to future situations. And the organization must have leaders who understand, encourage and engage on these levels.

Few institutions will fit snugly into a generic description of their processes and decision-making; rather, they are mix of varying approaches and calculi, and this will be true at different scales of the institution. Some departments or schools for example will use different methods and approaches—and with different results that will defy generic description. As a result, to gain a deeper understanding of an institution's level of resilience requires examination of the main processes and approaches used by institutions and the results or effects. Table 1 provides a synthesis of the elements within these dimensions.

The first dimension is a non-resilient position of maintaining status quo—whether by intent or in effect. In this environment, the operational process that guides the institutional is status quo (institutions don't set out a goal of status quo, so it requires examination of how they actually operate). Here the informal goal is to persist and preserve. It is a reactionary process of responding to crises or shocks in the system usually by linear, compartmentalized thinking. It is a singular focus on the problem and how to respond to the effects seen in the system. The status quo dimension inherently leads to a decline in value over time. Reactionary responses based on efficiency can yield both positive and negative value in the short run, but over the long run, these decisions inevitably lead to a loss of value (because diminishing return on efficiencies). This is not to say that there aren't times where short-run cutting of losses maybe the optimal choice; it can be. It simply means that intertemporal equity is critical to sustainability (Ortiz-de-Mandojana and Bansal 2015), and repeated short-run efficiencies or reducing resources or budget will eventually lead to a decline in value.

The second dimension is one best classified as adaptive resilience—a measure of a system's ability to survive and persist within a variable environment. Adaptation is a critical component of resilience, but adaptation alone is usually not sufficient to build value over time. In an adaptive mindset, the focus is on adjustments and improving the system (e.g. department, school, center). The focus is on optimization and shifting to meet changing demands. It remains largely reactive to exogenous forces but can be nonlinear and include diverse sets of decision-makers. Adaptation is critical to creating an elastic structure where the organization can address shocks and disturbances. However, the more you optimize or create efficiencies within a complex system, the more "you diminish that system's resilience" (Walker and Salt 2006) and its ability to be sustainable. Therefore, adaptation through optimization and resisting change through ever-increasing efficiencies can work against sustainability.

The final dimension of resilience is to work toward a building a system that perpetually endures—i.e. is sustainable. A resilient organization would be elastic, prepared, and opportunistic. It could effectively respond to the turbulence in a way that could improve the long-run outlook and value of the organization. The orientation to the crisis is through a holistic lens seeing the organization's fit and

Table 1 Classifications of organizational steps of resilience

Dimensions	Handmer/Dovers typology	Handmer/Dovers approach	Goal	Outcome	Mode	Improvement
Status quo	Type 1	No change necessary	Persist and preserve	Reduce value over time	Reactionary	Efficiency
	Resist change					
Adaptive (reactive) resilience	Type 2	Address symptoms	Adjust and improve	Maintain value over time	Reactionary elasticity	Optimization
	Change at margins					
Resilience t/w Sustainability (proactive)	Type 3	Address causes	Perpetually endure	Build value over time	Proactive elasticity	Opportunistic effectiveness
	Open and flexible					

function within greater systems. Using that holistic approach to not only adapt but to proactively pursue the institutional vision that can shift resources and align stakeholders across a diverse set of institutional boundaries allows the institution to strategically invest to meet longer-term goals. That is, the institution uses the crisis point as leverage to further strategic investment by seeing opportunities in a larger landscape and engaging in a constant learning process.

For example, a budget crisis emerges, where the projected enrollment is lower than expected. The status quo position is merely to cut the budget in various places —trying to be equitable about who shares in the burden of the cuts. Usually this is a simple measure of doing less with less; hence, the loss of value. The adaptive position is to see some tradeoffs within the process; to make some process or structural changes to optimize the system. In many ways, this adaptive approach leads to producing the same results with less (theoretically, relative no net loss in value over time). Finally, the resilience toward sustainability position would be to adapt to the new financial landscape through process or structural change, in ways that also produce a new path that generates internal value. Based on the new fault lines, the institution adapts while also creating new structure or programming that will enhance the deliverables in the longer run. Often, in a budget crisis, the resilient position toward sustainability requires some sacrifice of perceived value in the short run but is offset through a pathway to the future—a long-term strategic investment. In this position, the process of learning is the key feature in that over time, the organization can learn to recognize both the opportunity and to strategically invest to align with that opportunity.

To be clear, adaptation is usually a way of shifting to address a change, and in many instances it is the capacity to adjust in positive ways to an environmental change. Adaptation is part of resilience, but resilience toward sustainability provides in a proactive way, the opportunity to adapt in ways that build upon the adaptations to something better than it was before. So, you are building into the system both reactionary ways to deal with turbulence or shocks in the system, but also a proactive pathway for enhancing both the institution and the deliverables. In the instance of higher education, resilience allows the opportunity, through dealing with rapid change and uncertainty, to build a stronger institution and enhance the quality of the educational product.

For most institutions, resilience thinking helps to evaluate and quantify past outcomes while also identifying future pathways that can align resources and stakeholders to an elastic vision. By contrast, the linear, cost-cutting approach in the aforementioned example narrows opportunities for growth, and has the unfortunate by-product of engaging constituents in picking the "lesser evil" rather than creative solutions. This undoubtedly comes at a heavy price, as it can easily affect the morale, the culture and even the identity of the organization. This inevitably produces reactionary decisions that reinforce the status quo, leading to sub-optimal results that ultimately provide less value, one that can be further degraded as the community's social capital declines in that process.

Resilience thinking toward sustainability has enormous implications for an institution—as it can quickly become more competitive, enhance its reputational quality, and literally shift both the institution itself (to be higher quality of life) but also the value of the institution. From this perspective, in times of crises and uncertainty, this is an opportunity for many HEIs. What this also means is that, from a global perspective, it also has the added benefit of contributing to the larger field of sustainability and reshaping our understanding of sustainability.

4 A Framework for Organizational Resilience Toward Sustainability

From a sustainability perspective, institutional resilience requires adaptability complemented by constant learning within the organization. Donella Meadows eruditely suggests that all sustainable systems are composed of behavior that is self-organized, resilient and possesses some form of nested interconnectivity (Meadows 2008). So, thinking about organizational resilience leading toward sustainability requires a third element of interconnectivity (which can give rise to self-organization). All organizations have some connectivity (e.g. departments are connected in some fundamental way that helps generate a deliverable). Knowing some connections within an organization is different than "knowing that everything is interconnected" in your organization (Senge 2006). Some level of integration and continuity is necessary to serve the primary function of the organization, but generally, the more interconnected the framework and processes, the greater the level of resilience. These three elements—constant learning, adaptability and interconnectivity, form the backbone of institutional resilience as a goal toward sustainability as referenced in Table 2.

The *first* resilient component is constant learning, which must become embedded in the organizational culture (Kayes 2015), and it is composed of three main elements: (1) an environment conducive to learning, (2) entrepreneurial thinking, and (3) perspective and strategy. Without generating a process of organizational learning, the institution would otherwise rely on a series of reactive adaptations to change. It is critical that adaptation is supported by an embedded learning environment and process. The adaptation then becomes a *proactive* strategy based on entrepreneurial and creative thinking.

1. The first element is that of organizational learning is generating an **environment conducive to constant learning** in every aspect of organizational life (Senge 2006; Kayes 2015). Here, there is considerable overlap with sustainability—both as a concept and in application. According to Senge, organizational learning requires personal mastery (included in adaptation as personal resilience), mental models, shared vision, collaboration (see connectivity), and systems thinking (the core of sustainability thinking) (Senge 2006). The environment must offer a "cleared space" for ideas to germinate and mature, to map

Table 2 Framework for institutional resilience toward sustainability in higher education

Resilience components	Elements	Description
Learning	Perspective and strategy	Organizational knowledge and visionary strategy
	Entrepreneurial thinking	Individuals in community have opportunity to be creative and innovative (not bean counters)
	Environment of learning	Environment is one of constant learning with an emphasis on the integrity of the PROCESS
Adaptability	Change management	Leadership built on ability to transition
	Elasticity	Ability to reframe issues, to relocate resources, and to stretch org capacity and bounce back
	Personal resilience	Individuals within org community must be or have access to improve personal resilience
Interconnectivity	Interpersonal connection	The ability to build and regenerate social capital (or the glue) within organization
	Integration and continuity	The ability integrate knowledge and practices toward shared vision; the ability to create and dissolve structure
	Inclusiveness and equity	Ability to share in decision-making as part of an equitable environment—sense of belonging

those ideas to the problems at hand (adaptability), the ability to connect those ideas to people throughout the organization, and for those vetted ideas to emerge as part of the strategic initiative and culture of the organization. That is, the learning organization is in a constant state of renewal through the exchange of creative ideas and deepening relationships around the institution.

2. **Entrepreneurial thinking** involves individuals throughout the community possessing the *opportunity* to be creative and innovative in addressing the changing landscape in which the organization is embedded. This is critical because these are the folks usually with a direct hand in the deliverable—and in higher Ed, this represents daily interaction with students, other faculty and the curriculum. During times of crisis, the one element that drives resilience is the ability to innovate out of constraints. Often, in most institutions, there is not a dearth of creative talent and entrepreneurial thinking; the problem most often is the space to cultivate those ideas and/or the decision making is not matured.
3. The final element is **perspective and strategy**, where leadership must be able to access ideas, help galvanize support and resources, and ultimately implement them. Structurally, networked decentralized pathways facilitate this flow of information and knowledge without getting caught up in the hierarchical machine that often constrains the free flow of ideas. Thus, people at lower levels of the organization are just as much as the idea cultivators as those "making" the decisions at higher levels. The more network-like the organizational structure

and the greater the emphasis on creating a learning environment, the greater the value of lower-level input.

The *second* component of resilience is adaptive capacity, which is composed of (1) elasticity, (2) change management, and (3) personal resilience.

1. **Organizational elasticity** is the ability to bounce back after being stretched or compressed. So, as exogenous change naturally demands some internal response, that response allows the institution to recover or rebound. It is most often a consideration for operational and financial resilience—where operations must be flexible but also have restorative capacity. It is also the ability to reframe issues and problems. It is the capacity to stretch or relocate resources in ways that provide a restorative path—which when combined with learning, can offer a fresh and new pathway for managing complex problems.
2. **Change management** is the managerial capacity to cope with change, which naturally emphasizes the ability of leadership to transition. This requires effective "people managers" and the ability reframe issues and communicate them. It is the ability to vision and communicate that vision; otherwise, change can put morale and culture at risk. It is also the ability to create structure to adapt to problems, but also the capacity to dissolve it. Otherwise, a highly inefficient bureaucracy can result that undermines operational effectiveness and degrades interconnectivity, both of which often disrupt engagement and organizational culture that can occlude institutional identity.
3. **Personal Resilience** is the resilience capacity of individuals within the organization. It is extremely difficult to have organizational resilience on the backs of a few top-end leaders—even if those leaders are highly resilient. HEIs need resilient people throughout the organization who understand the larger vision of the institution, where they are included in understanding the depth of the problems or issues, and have the creative freedom within a constant learning environment. Without personally resilient individuals, this process can be overwhelming and can lead to greater disconnection as well as a loss of personal confidence and morale it is critical for an organization to provide opportunities for not only professional development but for enhancing personal resilience.

The *final* component of resilience organizations is interconnectivity, or the ability to be inclusive and connect people, resources, and ideas. The three elements of interconnectivity are: (1) interpersonal connection, (2) integration and continuity, and (3) inclusiveness and equity.

1. **Interpersonal connection** is a reflection of how people are connected within the organization. It is an active, ongoing process that builds critical social capital—a measure of the capital built through social networks. The key to building social capital is trust. The focus of the organization therefore should not only be upon enhancing interconnectivity through relationships, but building trust within and

amongst the community. This fosters reciprocity that is the building block for collaboration and establishing collaborative networks.
2. **Integration and Continuity** is the connectivity of ideas, knowledge and practices within the organization. Ideas in isolation cannot be vetted, improved or connected to help others to vest in those ideas. This process therefore becomes as important as the ideas themselves. Having a network structure can facilitate this integration and continuity by establishing "hubs" within the organization that serve as a collection point for ideas, feedback on those ideas, and to cultivate the ideas for action. It also provides an essential high profile physical location for additional information and knowledge building.
3. **Inclusiveness and Equity** is the capacity and opportunity for shared governance, and to be included within the decision-making of the organization. Inclusiveness also ensures diversity, and to participate within an equitable environment. Without equity, diversity and inclusiveness, the morale and level of engagement can easily undercut quality ideas, adaptive measures, and social capital. Inclusiveness and equity are essential to establishing a "sense of belonging" and appreciation that gives community members a deeper sense of purpose and direction.

These three components of resilience combine in important ways that speak to the broader picture of building a sustainable organizational life. Beyond these elements, the organization must have the capacity for replication—where those desired paths and behaviors can be replicated as part of the structure to shift and enhance the culture of the organization (Everyly 2011). It also helps to generate a community or organizational identity that also enhances organizational culture. A clear understanding of identity is a bonding perception that helps to overcome the small bumps or turbulence within your own organizational framework and process. It is also very important to establish trust within the organization, one that can then influence other organizations and the greater community. It becomes an attractor to overcome doubt and fear that usually results in a risk-averse culture that engenders status quo.

5 Conclusion

SD requires institutions capable of producing development with environmental protection, social inclusion and equity. These institutions must operate in ways that embody sustainability thinking to drive sustainable development. In many ways, this requires building sustainable institutions—organizations that can perpetually endure, to actively participate and lead by example. However, this is difficult in a complex, turbulent and uncertain world. This is particularly true for HEIs, which are regular practitioners of sustainability and who are teaching and guiding the next generation of citizens to engage in this complex, turbulent world.

An institution, by definition, cannot be "sustainable" in isolation. It is embedded within systems and is therefore a reflection to some degree of and to those systems. Proactive resilience or resilience toward sustainability represents a clear paramount goal for HEIs that embodies both an operational outcome and a mission for greater engagement to alter those larger systems in which it is embedded. Institutional resilience becomes a feature of sustainability that helps to facilitate those sustainability values throughout the institution and into broader systems. In essence, a resilient organization represents sustainability values and practices those values in ways that contribute directly to sustainable development while also driving at systems' change. It builds intellectual, social, ecological, and political capital for the institution that impacts the greater community in positive ways. This is a representative pathway to address what Sterling rightly recognizes as HEI's incapacity to adapt to the unsustainable systems' "conditions we face".

References

AASHE. (2016). *Mission, vision and goals*. Association for the Advancement of Sustainability in Higher Education. http://www.aashe.org/about/aashe-mission-vision-goals (Last Accessed March 10, 2016.

Barnard, Z., & Van der Merwe, D. (2016). Innovative management for organizational sustainability in higher education. *Int'l Journal of Sustainability in Higher Education, 17*(2), 208–227.

Cortese, A. D. (2003). The critical role of higher education in creating a sustainable future. *Planning for Higher Education, 31*(3), 15–22.

Everyly, G., Jr. (June 24, 2011). Building a resilience organizational culture. *Harvard Business Review*.

Ferrer-Balas, D. J., Adachi, S., Banas, C. I., Davidson, A., Hoshikoshi, A., Mishra, Y. et al. (2008). An international comparative analysis of sustainability transformation across seven universities. *International Journal of Sustainability in Higher Education*, *9*(3), 295–316.

Folke, C. (2006). Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change, 16*, 253–267.

Handmer, J., & Dovers, S. (1996). A typology of resilience: Rethinking institutions for sustainable development. *Organization and Environment, 9*(4), 482–511.

Holling, C. S. (1996). Engineering resilience versus ecological resilience. In Shulze (Ed.), *Engineering with ecological constraints* (pp. 31–44). Washington DC: National Academy Press.

Homer-Dixon, T. (2012). *Our panarchic future*. Washington DC: Worldwatch Institute. Available at: http://www.worldwatch.org/node/6008 (Accessed March 10, 2016).

Kayes, C. (2015). *Organizational resilience: How learning sustains organizations in Crisis, disaster, and breakdown*. Oxford: Oxford University Press.

Korhonen, J., & Seager, T. P. (2008). Beyond eco-efficiency: a resilience perspective. *Business Strategy and the Environment, 17*, 411–419.

Krizek, et al. (2012). Higher education's sustainability imperative: how to practically respond? *International Journal of Sustainability in Higher Education, 13*(1), 19–33.

Meadows, D. H., Meadows, D. L., & Randers, J. (2005). *Limits to growth: The 30-year update*. London: Earthscan.

Meadows, Donella. (2008). *Thinking in systems: A primer*. White River Junction, VT: Chelsea Green Publishing.

Moran, B., & Tame, P. (2012). Organizational resilience: Uniting leadership and enhancing sustainability. *Sustainability, 5*(4), 233–237.
Ortiz-de-Mandojana, N, & Bansal, P. (2015). The long-term benefits of organizational resilience through sustainable business practices. *Strategic Management Journal* (online).
Seligman, M. E. P. (2011). Building resilience. *Harvard Business Review*.
Senge, P. (2006). *The fifth discipline: The art and practice of the learning organization*. New York: Doubleday.
Sterling, S., Maxey, L., & Luna, H. (2013). *The sustainable university: Progress and prospects*. New York, NY: Routledge.
Tainter, J. (1990). *The collapse of complex societies*. Cambridge, UK: Cambridge University Press.
Walker, B, & Salt, D. (2006). Resilience Thinking: Sustaining Ecosystems and People in a Changing World.
Wright, T. S. A. (2002). Definitions and frameworks for environmental sustainability in higher education. *Higher Education Policy, 15*(1), 105–120.

Author Biography

P. Brian Fisher is the Director of Sustainability and Associate Professor of Political Science at the College of Charleston (USA). He created the Office of Sustainability in August of 2011, based on an holistic three-part approach to sustainability through operations management, research and teaching. He is responsible for daily management of campus sustainability, including accounting for energy and waste operations, as well as generating cultural and social approaches to sustainability. He has taught classes on Sustainability Management, Applied Sustainability, Sustainable Development, Systems Thinking, Social Sustainability, Security and Sustainability, and Environmental Policy and Law. He has published articles on global climate governance, human security and climate change in vulnerable communities, the concept of sustainability, and sustainability in higher education.

The Campus as a Living Laboratory: Macalester College Case Study

Suzanne Savanick Hansen

Abstract

All higher education campus buildings and grounds can be studied, analyzed and even manipulated for research and education. However, higher education faculty do not typically use their own campus as a living laboratory. At most institutions, a student's education does not link to the local context, and students are unaware of an institution's sustainability footprint. This paper analyzes the effectiveness of one living laboratory case study at Macalester College in St. Paul, Minnesota, USA. This paper describes Macalester College's living laboratory program and the classes, independent studies, and academic internships that have used the living laboratory approach. The schools' program strengths and weaknesses are analyzed by using the "Eight Elements to Building a Living Lab" framework identified by the Sustainability Education and Economic Development (SEED) Center's "The Campus as a Living Laboratory" guidebook. Recommendations to improve the living laboratory program are also included.

Keywords

Living laboratory · Campus-based learning · Education for sustainability · Campus sustainability · Macalester College

S.S. Hansen (✉)
Sustainability Office, Macalester College, 1600 Grand Ave,
St. Paul, MN 55105, USA
e-mail: shansen2@macalester.edu

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_14

1 Introduction

At most higher educational institutions, education does not link to the local environmental context, and students are unaware of their institution's sustainability footprint. Typically, the campus buildings and grounds are a backdrop for the education that happens inside the classrooms. However, a growing number of schools are using their campus buildings and grounds as explicit educational tools for sustainability education; this concept is increasingly called "using the campus as a living laboratory." At the smallest scale, an instructor can illustrate a concept during a lecture by using a campus example. At a much larger scale, a multi-year interdisciplinary project could be undertaken with facilities management staff to have students research and design a new campus building with environmentally beneficial components. At any scale, the campus can act as a teaching lab where students can see the local, concrete links to theoretical concepts. The living laboratory concept can also be extended to include the community where the educational institution resides.

The living laboratory concept originally started as an outgrowth of the green building focus in architecture. One of the early examples of a higher education building used as a living laboratory in the United States is Oberlin College's Adam Joseph Lewis Center, built in 2000. It was one of the first green buildings to specifically use the building as a teaching tool. The building has over 150 sensors that give real-time feedback about energy and material flows (http://new.oberlin.edu/office/environmental-sustainability/progress/buildings.dot). Using new education buildings as living laboratories is relatively common in the architecture field. Many schools at all levels have been intentionally developed as teaching tools using the Leadership in Energy and Environmental Design (LEED) Green Building Rating System. The Center for Green Schools showcases many of these examples on their website (http://www.centerforgreenschools.org/).

A growing number of higher educational institutions are also creating living laboratory programs that use their campuses as a living laboratory, even without a new building. At Portland State University, an early leader in this area, the "Living Lab" is a partnership between the Campus Sustainability Office and the Institute for Sustainable Solutions. The program matches faculty and students with university staff, and the program meets operational needs while providing students with hands-on educational opportunities (http://www.pdx.edu/sustainability/living-lab). Another example is Penn State University, which includes an explicit mention of living laboratories in their Sustainability Strategic Plan. In addition, Princeton University recently developed a comprehensive living laboratory website (https://sustain.princeton.edu/lab) where academic research opportunities are listed, projects are archived and sustainability efforts are noted.

Organizations that assist schools with campus sustainability, such as the Association for the Advancement of Sustainability in Higher Education (AASHE) in the United States, also promote the use of buildings and grounds as living laboratories. In AASHE's Sustainability Tracking, Assessment and Rating System (STARS), which is used to rate sustainability efforts in higher education, points are given for using the campus as a living laboratory. The rationale for credit states,

> This credit recognizes institutions that utilize their infrastructure and operations as living environments for multidisciplinary learning, applied research and practical work that advances sustainability on campus. Students that actively participate in making their campuses more sustainable are well prepared to continue that work in their careers and communities after graduation (AASHE 2014).

As of January, 2016, 110 out of 178 schools participating in the STARS program have a 4-star rating in this credit, which means approximately 62 % of colleges answering this question in STARS have the highest rating possible.

As the living laboratory concept gained popularity, resources have been developed for campuses interested in utilizing the living laboratory approach. The most comprehensive resource specifically for living laboratory programs is "*The Campus as a Living Laboratory: Using the Built Environment to Revitalize College Education*" (Cohen and Lovell 2013). This guidebook, created by the Sustainability Education and Economic Development (SEED) Center, is designed as a resource for community colleges but is useful for all types of higher education institutions. In addition, the United States Green Building Council (USGBC) also hosts the Center for Green Schools that specifically looks at ways to connect education and buildings, particularly Leadership in Energy and Environmental Design (LEED) buildings. Their "*Roadmap to a Green Campus*" resource includes a chapter on campuses as living laboratories (Humblet et al. 2010). Finally, the Science Education Resource Center hosts a recently updated "Campus Living Laboratory" web module developed for geoscience faculty who want to develop a living laboratory project in their class (Hansen et al. 2015).

Using a university or college buildings and grounds as sustainability education tools is one approach to Education for Sustainable Development. According to the United Nations, "Education for Sustainable Development (ESD) allows every human being to acquire the knowledge, skills, attitudes and values necessary to shape a sustainable future" (UNESCO 2016). ESD involves adding key sustainable development issues into teaching and learning and requires participatory methods that empower learners to change their behavior and take action for sustainable development (UNESCO 2016). Using the campus as a living laboratory is a tool for ESD. Some of the living laboratory projects may lead to behavior change by individual and institutions; these projects give students an opportunity to take action in support of sustainable development.

Using the campus as a living lab is a type of service-learning. Service-learning is a combination of community service and academic learning where students work on community volunteer projects as part of their educational experience. The use of service-learning has shown to improve academic learning and student satisfaction (Astin et al. 2000; Eyler et al. 2001).

Using the campus as a living lab also promotes civic engagement. Many colleges and universities are beginning to emphasize educating society about civic responsibilities as a crucial element, if not the purpose, of education (Boyte and

Hollander 1999; Kellogg Commission on the Future of State and Land-Grant Universities 2000). If the students recommend action or use their study to improve the environment on the campus, the students have the opportunity to become engaged in the civic activity of the college or university.

This paper analyzes the effectiveness of one living laboratory case study at Macalester College in St. Paul, Minnesota, USA. This paper describes Macalester College's living laboratory program and the classes, independent studies, and academic internships that have used the living laboratory approach. The schools' program strengths and challenges are analyzed by using the "Eight Elements to Building a Living Lab" identified in the SEED Center's "*The Campus as a Living Laboratory*" guidebook (Cohen and Lovell 2013). Recommendations to improve the living laboratory program are also included.

2 Methodology

This paper analyzes the living laboratory approach to sustainability education at Macalester College by analyzing how well the efforts fit with the SEED Center framework. First, the Sustainability Manager listed the classes and academic projects using a living laboratory approach. For each project or class, the department, activity type, topic and a note on how the project started is noted. The topics were grouped by type: climate change-related, zero waste, communication, sustainability assessments, landscaping/stormwater, and food. Next, the Sustainability Manager analyzed the how well the program fares under each of the eight elements identified by the SEED center by describing the effort in that area and assigning a numeric score. The scores were plotted on a spider graph to highlight the strong and weak areas of the program.

3 Macalester College Living Laboratory Case Study

Macalester College is a small liberal arts college located in an urban residential area of St. Paul, Minnesota, USA. The college enrolls approximately 2000 students, and employs 180 faculty and 390 staff. In 2007, the college president signed the American College and University Presidents' Climate Commitment, committing the college to achieving climate neutrality. As a result, the Sustainability Office was established with the hiring of the first Sustainability Manager in 2008. The Sustainability Office handles reporting for sustainability commitments, manages the campus-wide Sustainability Plan, and works with students, staff and faculty to improve the sustainability of the campus. The Sustainability Plan came about through a participatory strategic planning process and a class project (Hansen et al. 2011).

As the Sustainability Manager had a specific interest in using the campus as a living laboratory, one of the focuses of the Sustainability Office has been supporting the use of the campus as a living laboratory. The Sustainability Manager teaches classes and supervises independent studies and internships. In addition the office supports faculty with campus sustainability course projects, archives student projects, facilitates data accessibility, and follows up on student recommendations. The Sustainability Office also hosts a data and reports archive on the Sustainability Office website to make campus data available to faculty and students. In addition, the office developed a list of campus sustainability-related field trip locations, campus sustainability data sets and reports. The office also posted a "potential student projects list" on the office website to connect interested faculty and students with sustainability projects on campus.

Many of the classes that are part of the living laboratory program are Environmental Studies classes. The Environmental Studies Department faculty also advises the EcoHouse student residence. The EcoHouse is a small campus house that was renovated using sustainability criteria and was designed as a living learning laboratory by and for students (Wells et al. 2009).

Other departments with a role in the living laboratory program include the Jan Serie Center for Scholarship and Teaching (Serie Center) and the Institute for Global Citizenship (IGC). Sustainability education topics are occasionally included in regular faculty development workshops and lunches at the Serie Center. The IGC hosts a grant funded Educating Sustainability Ambassadors program that offers faculty development, international sustainability faculty trips, and student sustainability conversations. One of the additional programs of the IGC, the Civic Engagement Center, also connects faculty with community partners for service-learning projects and volunteer activities.

4 Living Laboratory Academic Projects

Table 1 lists academic living laboratory projects by academic experience, department, activity type, topic, project and how the project started. Routinely offered classes are given in bold. Note that the table only lists the projects known to the Sustainability Office. Other classes and student papers may have been completed, but they were not part of the Sustainability Office's living laboratory program.

A total of 23 academic experiences were identified as living laboratory projects; five are regularly offered classes. The academic experiences range from full senior seminar classes to small class papers. In addition to classes, living laboratory projects were part of academic internships and independent study classes. The list includes a significant number of research projects. Many of these research projects were part of required senior seminar classes, particularly environmental studies

Table 1 Living laboratory academic projects at Macalester College

Academic experience	Department	Activity type	Topic	Project	How project started
Senior Seminar Class	Environmental Studies	Major class project	Climate change	Calculated campus greenhouse gas emissions	Sustainability Manager co-taught class
Senior Seminar Class	Environmental Studies	Major class project	Climate change	Recommended actions for campus climate action plan	Sustainability Manager taught class
Senior Seminar Class	Environmental Studies	Major class project	Zero waste	Researched zero waste projects for campus, including composing	Sustainability Manager co-taught class
Senior Seminar Class	Environmental Studies	Major class project	Communication	Developed communications projects for campus field station	Instructor interest
Senior Seminar Class	Environmental Studies	Major class project	Communication	Developed campus Earth Day activities	Instructor interest
Senior Seminar Class	Environmental Studies	Major class project	Climate change	Researched renewable energy for campus	Students found topic in the Sustainability Plan
Senior Seminar Class	Geography	Major class project	Climate change	Recommended ways to more effectively calculate airline travel emissions as well as how to reduce travel	Students found topic in the Sustainability Plan

(continued)

Table 1 (continued)

Academic experience	Department	Activity type	Topic	Project	How project started
Sustainability and the Campus Class	**Environmental Studies**	**Major class project**	**Sustainability assessment (climate change, zero waste, communication)**	**Recommended actions for the Center for Religious and Spiritual Life**	**Sustainability Manager taught class**
				Researched solar options for campus-owned buildings	
				Developed sustainable special events guide	
				Developed sustainability education materials for campus language houses	
Cities, Sustainability and the Campus Class	Environmental Studies	Major class project	Communication	Developed campus signage for Earth Day	Sustainability Manager taught class
			Zero waste	Analyzed sustainability efforts in the Athletics Department	
				Recommended compostable dishware for the dining hall	
Cycling the Urban Landscape Class	Environmental Studies	Class project	Climate change	Recommended actions for improving bicycling infrastructure on campus	Faculty interest
Environmental Science Class	Environmental Studies	Class project	Landscaping/Storm water	Analyzed the potential for a green roof on a dormitory	Facilities Director recommended project
Psychology for Sustainable Behavior Class	**Psychology/Environmental Studies**	**Class project**	**Climate change**	**Developed recommendations for campus energy and waste projects**	**Faculty interest**
			Zero waste		

(continued)

Table 1 (continued)

Academic experience	Department	Activity type	Topic	Project	How project started
Hydrology Class	Geology	Class project	Landscaping/Storm water	Calculated runoff from different campus areas	Sustainability Manager recommended project
Science of Renewable Energy Class	**Physics/Environmental Studies**	**Class activity**	**Climate change**	**Analyzed the effectiveness of campus wind turbine**	**Faculty interest**
Social Science Inquiry Class	**Sociology/Political Science**	**Class project**	**Communication**	**Surveyed attitudes about sustainability, composting, energy**	**Sustainability Manager recommended project**
Architecture, Sustainability and Place-Making Class	Environmental Studies	Major class project	Green building	Envisioned the architecture of a college field station	Sustainability Manager recommended project
Introduction to Statistical Modeling Class	Math, Statistics and Computer Science	Major class project	Climate change	Analyzed commuter data	Faculty interest
			Zero waste	Analyzed composting data	Student interest
Honors Thesis	Math, Statistics and Computer Science	Thesis	Climate change	Analyze energy use in all college dormitories	Student interest
EcoHouse Research Project	Environmental Studies	Independent study	Zero waste	Documented and analyzed all waste from a campus house	Student interest

(continued)

Table 1 (continued)

Academic experience	Department	Activity type	Topic	Project	How project started
EcoHouse Research Project	Environmental Studies	Independent study	Climate change	Analyzed the different energy use in two campus houses	Sustainability Manager recommended project
EcoHouse Research Project	Environmental Studies	Internship	Food	Developed student guide to Eating Sustainably on a Budget	Student interest
Markim Hall Research Project	Partnership with Dakota County Technical College	Internship	Green building	Summarized documentation for a LEED platinum building	Sustainability Manager recommended project
				Developed community guide to green building materials for EcoHouse	
Research Project	**Partnership with University of Minnesota Landscape Architecture Class**	**Class project**	**Landscaping/Storm water**	**Designed possible new green roof designs**	**Faculty interest**

senior seminar classes. A math, statistics and computer science student also used a living laboratory approach to an honors thesis. Students also used the EcoHouse student residence as an independent study or internship research project.

The most common topic for the academic experiences using a living laboratory approach was climate change with 10 living laboratory projects listed. The second most common topic was zero waste with five living laboratory projects. Many of these zero waste projects focused on composting. Other topic areas included communications (three listed), sustainability assessments (three listed), landscaping/storm water (three listed) and food (one listed).

Environmental studies is the most common department using the living laboratory approach. Other departments listed include the following: geology, sociology/political science, math/statistics/computer science, geography, psychology, physics, and architecture. Almost all of the classes are from Macalester College. However, the class listing includes one University of Minnesota landscape architecture class that uses Macalester College as a case study site location. In addition, a student at Dakota County Technical College used Macalester College as an academic internship site.

Many of the living laboratory projects started because the Sustainably Manager taught or co-taught the class, suggested the topic, or students found the topic in the Sustainability Plan. Classes also included projects because the topic was already a research interest of the instructor.

5 Analysis

The most comprehensive resource for colleges interested in developing a living laboratory is "*The Campus as a Living Laboratory: Using the Built Environment to Revitalize College Education*," developed by the SEED center (Cohen and Lovell 2013). The guidebook describes "Eight Elements to Building a Campus Living Laboratory" as: Engage the right campus participants, ID key collegiate programs, Build credibility through engagement and data, Integrate into curriculum, Expand beyond individual programs of study, Build partnerships with industry, Engage support beyond campus, and Open your labs to the community.

Macalester College's living laboratory program was evaluated for the purposes of this paper using these eight elements. The Sustainability Manager scored how well Macalester College's living laboratory program fits the SEED Center elements on a zero-to-three scale: 0, no work in this area; 1, minor work in this area; 2, some work in this area; 3, significant amount of work in this area. Scoring was self-reported by the Sustainability Manager.

6 Eight Elements to Building a Campus Living Lab and Macalester College

1. **Engage the right campus participants**

According to the SEED Center, key participants include the course instructor, Division Chair, Academic Dean, Facilities Director, and Human Resources Director. By including the right participants, a campus can move a living laboratory program from a single course to a strategic initiative (Cohen and Lovell 2013).

(Score 1: Minor work in this area) Of the key participants listed, only the course instructor and the Facilities Director have been engaged in living laboratory projects at Macalester College. However, the core of the living laboratory program is facilitated by the Sustainability Office and sustainability staff is not included in the SEED center list. At Macalester College, the living laboratory program is also not well connected to other potential areas that could be allies, such as the Serie Center and the IGC.

2. **ID key collegiate programs**

The SEED Center highlights the following academic programs as good fits for living laboratory programs: agriculture, business and accounting, engineering, environmental science, physics, and psychology (Cohen and Lovell 2013).

(Score 3: Significant amount of work in this area) All of the key collegiate programs that Macalester College offers are on the SEED Center list. The classes at Macalester College that use a living laboratory approach have been in environmental studies, physics, psychology and geography. As a small liberal arts college, Macalester does not offer agriculture, business, or engineering classes in the curriculum. Macalester's living laboratory program has been used in some departments not listed above: geography, geology, and math, statistics and computer science.

3. **Build credibility through engagement and data**

The SEED Center notes that "early wins are essential to build momentum" with institutional change projects. In the SEED Center examples, student projects showed significant cost savings, engaged a wide number of partners, quantified the impact on students, and brought in additional money (Cohen and Lovell 2013).

(Score 1: Minor work in this area) At Macalester College, student projects have often been able to highlight an issue or change a practice on campus. For example, student data from a composting project provided the needed support for adding composting campus-wide. Data from the EcoHouse energy efficiency independent study project also saved the college money by identifying a basement dehumidifier left running continually in the winter.

The Sustainability Office collects student papers when these papers are available, and the environmental studies program archives student projects on the website. However, there has not been a systematic collection or sharing of the specific cost savings or impacts of the student work with upper level administrators.

4. **Integrate into curriculum**

The SEED center notes that, at minimum, instructors need to include the following in the syllabus: a full description of the project, including the topic's connection to the college's broader sustainability goals, student learning outcomes, where and when the work will take place, expectations for on-site behavior, safety issues to keep in mind, and student work expectations (Cohen and Lovell 2013).

(Score 2: Some work in this area) At Macalester College, instructors typically include in their syllabi project descriptions, learning outcomes, logistics, safety guidelines and student work expectations. However, instructors do not necessarily include the topic's connection to the college's broader sustainability goals.

5. **Expand beyond individual programs of study**

The SEED center recommends starting with small projects within a single course. More experienced instructors could collaborate with faculty and staff on interdisciplinary projects that can build students' system thinking skills (Cohen and Lovell 2013).

(Score 0: No work in this area) At Macalester College, all of the projects have been individual courses, independent studies or internships. Many of the courses that were co-taught by the Sustainability Manager were co-taught by an environmental studies professor. The classes may have an interdisciplinary focus, but no efforts have been made to team teach across classes in other disciplines or to teach across multiple classes.

6. **Build partnerships with industry**

The SEED Center noted that the successful living laboratory programs typically have an industry partner involved (Cohen and Lovell 2013).

(Score 3: Significant amount of work in this area) Macalester College has partnered with industry partners on living laboratory projects. First, the local utility, Xcel Energy, supported EcoHouse outreach efforts through a grant. In addition, TRANE donated equipment for metering the EcoHouse. Recently, MAMAC Systems partnered with the college to install energy meters and test the effectiveness of real-time data communication feedback. MAMAC donated some of the equipment and supported student research.

7. **Engage support beyond campus**

The SEED Center recommends finding partnerships in the local community where students can work on sustainability efforts though using the community as a living laboratory (Cohen and Lovell 2013).

(Score 1: Minor work in this area) At Macalester College, the Civic Engagement Center connects instructors to community partners with service learning projects and volunteer activities. However, these projects are not typically seen as part of the campus sustainability efforts or as an extension of the living laboratory program. The Civic Engagement Center works off-campus exclusively while the campus sustainability office specifically works on campus. However, both programs have similar goals and theoretical underpinnings, so collaboration could be feasible.

8. **Open your labs to the community**

The SEED center recommends using a campus living laboratory as a model for the community through utilizing tours and field trips, signage, web presence, and workshops (Cohen and Lovell 2013).

(Score 2: **Some work in this area)** The Sustainability Office routinely offers sustainability tours of campus, and sustainability staff routinely give off-campus presentations. The Sustainability Office also works closely with the Upper Midwest Association for Campus Sustainability, the regional campus sustainability organization. The Sustainability Office also developed a printed sustainability campus tour map and a self-guided tour for the LEED platinum building on campus. The campus prairie and wind turbine have educational signs, but most of the other sustainability projects on campus do not have signage. Also, the sustainability office has limited web information on the office website about the living laboratory program.

Figure 1 shows a spider diagram of Macalester College's scores from the SEED Center eight elements for campus living laboratory programs. The elements are listed around the diagram. Scores close to the middle are weak areas for the living laboratory program. Scores on the outside are strong areas for the living laboratory program.

The Macalester College Living Laboratory program scored highly with a "3" in the areas of "ID key collegiate programs" and "Build partnerships with industry." All of the key collegiate programs identified by the SEED Center that Macalester College offers have been involved in the living laboratory program. The Sustainability Office also has one solid partnership with an industry partner, and the college has engaged three industrial partners for projects.

The college scored a "2" in the areas of "Integrate into curriculum" and "Open your labs to the community." While instructors using a living laboratory approach often include material about the projects in their syllabi, they do not necessarily provide links to the larger sustainability goals of the college. The Sustainability Office has done a good job of educating the local community about the sustainability projects on campus by hosting tours and developing educational material,

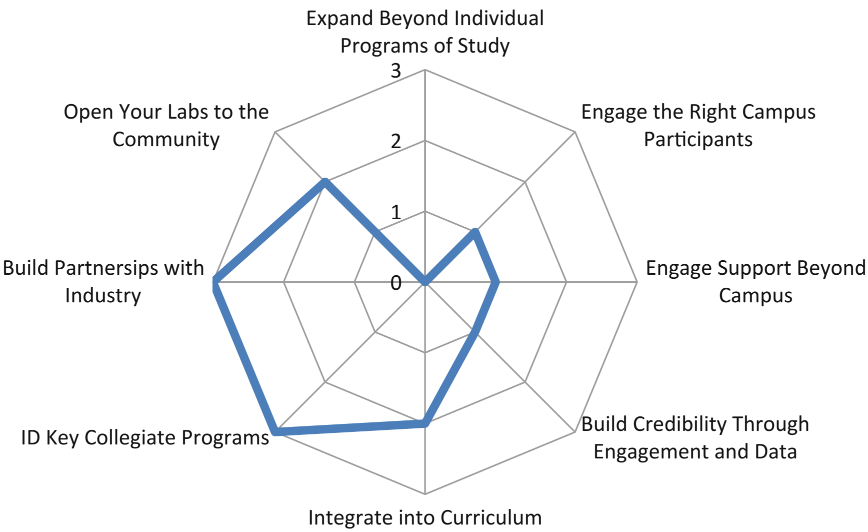


Fig. 1 Macalester College scores in the eight living laboratory elements

but many of the projects on campus have no signage. Information about campus sustainability is on the website, but the website is lacking specific living laboratory information.

The college scored a "1" in the areas of "Engage the right campus participants," "Build credibility through engagement and data," and "Engage support beyond campus." The Sustainability Office has engaged some, but not all, of the key personnel needed for a living laboratory to be successful. Macalester College has a supportive facilities and sustainability staff actively working on making the campus a living laboratory. However, gaining the attention of high-level academic administrators would be needed to move beyond the individual course approach.

Data has been used to change the campus, and individual classes have had impact, but the college's living laboratory program has not yet engaged beyond individual instructors and personal connections of the Sustainability Manager. The college has yet to fully institutionalize the program by engaging with senior personnel on the academic side of the institution. In addition, the living laboratory program does not connect well with the already existing IGC and Serie Center.

The college scored a "0" in "Expand beyond the individual programs of study." All of the living laboratory projects have been in individual classes, and most of the classes are environmental studies classes. Although the environmental studies courses use an interdisciplinary approach, there is an opportunity to engage disciples in larger interdisciplinary projects.

7 Lessons Learned

Based on the analysis of Macalester College's living laboratory program though the eight criteria set forth by the SEED Center, the following recommendations are given to improve the program:

- Macalester College should continue to seek out industry and grant support for the living laboratory program.
- The Sustainability Office should make sure that individual course instructors have suggested language about how the project fits with the larger sustainability goals.
- The college should also focus on improving campus sustainability signage and bolster the living laboratory website.
- The Sustainability Office should look for ways to engage with other departments that currently work with faculty, such as the Serie Center and the IGC.
- The Sustainability Office should actively engage upper administration to highlight the results of the living laboratory projects.
- The Sustainability Office and the Civic Engagement Center should look for ways to link the campus living laboratory with the work already underway in the community.
- The Sustainability Office should expand on the current interdisciplinary projects in environmental studies to incorporate other disciplines not currently working with the living laboratory program.

8 Conclusion

Macalester College Sustainability Office has built a living laboratory program through teaching classes, working with environmental studies faculty, and assisting faculty in incorporating projects into existing classes. This paper analyzed Macalester College's program by using the "Eight Elements to Living Lab Programs" identified by the SEED Center (Cohen and Lovell 2013). Macalester College's program does a good job of partnering with key participants and with industry. The school could improve by making sure that faculty include the links to wider sustainability efforts in course syllabi, as well as improve signage and web presence. The school could further improve by moving beyond the individual class paradigm. The college should develop ways to engage the upper administration with the results of the projects already underway and move to partner more closely with departments that have a congruent mission, such as the Institute for Global Citizenship and Serie Center.

Higher education intuitions have an opportunity to improve sustainability education through using a living laboratory approach. Tools and resources are currently available, such as the SEED Center guidebooks used in this analysis, so educational institutions can build on experiences at other locations. This paper shows how one higher education institution used existing resources to improve the Sustainability Office's approach to using campus buildings and grounds as a living laboratory for sustainability education. By using the buildings, grounds and local community as living laboratory sites, higher education can both educate students and offer solutions for the challenges of sustainable development.

References

AASHE. (2014). *STARS 2.0 Technical Manual—Administrative Update Two*. Association for the Advancement of Sustainability in Higher Education. http://www.aashe.org/files/documents/STARS/2.0/stars_2.0.2_credit_ac_8.pdf.

Astin, A., Vogelgesang, L., Ikeda, E., & Yee, J. (2000). *How service-learning affects students*. Los Angeles: ULCA Higher Education Research Institute.

Boyte, H., & Hollander, E. (1999). *Wingspread declaration on the civic responsibilities of research universities*. http://compact.org/wingspread-declaration-on-the-civic-responsibilities-of-research-universities/.

Cohen, T., & Lovell, B. (2013). *The campus as a living laboratory: Using the built environment to revitalize college education: A guide for community colleges*. Sustainability Education and Economic Development (SEED) Center. http://www.theseedcenter.org/getattachment/Resources/SEED-Resources/SEED-Toolkits/Campus-as-a-Living-Lab/Campus-as-a-Living-Lab.pdf.

Eyler, J., Giles, D., Stenson, C., & Gray, C. (2001). *At a glance: What we know about the effects of service-learning on college students, faculty, institutions, and communities 1993–2000*. Learn and Serve America National Service Learning Clearinghouse.

Hansen, S. S. (2015). Campus living laboratory. *Campus Living Laboratory*. http://serc.carleton.edu/introgeo/campusbased/index.html.

Hansen, S. S., Bucki, J., & Lee, J. (2011). Engaging the campus community through participatory sustainability strategic planning. *Sustainability: The Journal of Record*, 4(2), 75–79.

Humblet, E., Owens, R., & Roy, L. P. (2010). *Roadmap to a Green Campus*. U.S. Green Building Council. http://www.centerforgreenschools.org/sites/default/files/resource-files/RoadmaptoaGreenCampus_online_121611.pdf.

Kellogg Commission on the Future of State and Land-Grant Universities. (2000). *Renewing the covenant: Learning, discovery, and engagement in a new age and different world, 6th report*. National Association of State Universities and Land-Grant Colleges. http://www.aplu.org/projects-and-initiatives/economic-development-and-community-engagement/Kellogg%20Commission%20on%20the%20Future%20of%20State%20and%20Land-Grant%20Universities/.

UNESCO. (2016). *Education for sustainable development*. Accessed March 10. http://www.unesco.org/new/en/education/themes/leading-the-international-agenda/education-for-sustainable-development/.

Wells, C., Savanick, S., & Manning, C. (2009). Using a class to conduct a carbon inventory: A case study with practical results at Macalester College. *International Journal of Sustainability in Higher Education*, *10*(3), 228–238. doi:10.1108/14676370910972549.

Author Biography

Suzanne Savanick Hansen is the Sustainability Manager at Macalester College. She works with students, staff and faculty to advance sustainability projects across the college. She currently implements the college's first comprehensive sustainability plan and is developing ways to use buildings and grounds as teaching tools. She earned her Ph.D. in conservation biology from the University of Minnesota, a master's degree in environmental management from Duke University and a bachelor's degree in geology from Carleton College. She previously developed the Sustainable Campus Initiative at the University of Minnesota, worked for the Science Education Resource Center at Carleton College, the Minnesota Office of Environmental Assistance and served as an elected supervisor of the Dakota County Soil and Water Conservation District.

Sustainable Energy Campus: A Challenge on Smart Facilities and Operations

Paulo Ferrão and Mário de Matos

Abstract

The annual electricity consumption on the Alameda Campus of Instituto Superior Técnico (IST), University of Lisbon, was around 14 GWh with a 1 MW base load, between 2006 and 2010. With the purpose of improving the overall energy efficiency within IST facilities, the "Sustainable Campus at Técnico" project was set in motion in 2012 as part of an energy management policy, which engaged different skills across the IST community. This paper describes the key activities carried out by staff, faculty, students and researchers, under the IST Energy Initiative. These encompassed energy and water usage audits, as well as the development of new auditing tools and thermal computational models of all campus buildings, the classification of activity indexes, occupancy levels and the installation of energy meters designed and manufactured by IST researchers. The implementation of no-cost energy conservation measures comprised awareness-raising and best practice adoption with the participation of operations and maintenance staff. Technical operations personnel have been given guidelines on energy-saving measures, and the remaining campus staff was encouraged to participate in energy and water-conservation activities. Measures to improve on-campus energy efficiency included the application of sun control window film in both glazed towers of the campus, as a consequence of the energy-saving estimates evidenced by computational simulations. The results achieved so far, which are explained in detail in this paper, show a significant decrease in electricity consumption, from

P. Ferrão
Department of Mechanical Engineering, Instituto Superior Técnico,
University of Lisbon, Av. Rovisco Pais nº1, 1049-001 Lisbon, Portugal

M. de Matos (✉)
Management Board, Instituto Superior Técnico, University of Lisbon,
Av. Rovisco Pais nº1, 1049-001 Lisbon, Portugal
e-mail: mario.matos@tecnico.ulisboa.pt

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_15

14 to 11.5 GWh, and a decrease from 1000 to 850 kW base load, which represents almost 20 % in energy savings, for the same level of service.

Keywords
Sustainable campus · Energy efficiency · Energy conservation measures

1 Introduction

Engineering university campuses include a core cluster of complex buildings, such as laboratories, which require a great deal of energy and water, use up large materials and generate a lot of waste, with all associated environmental impacts. Technical universities educate future engineers, who will become active players with values apprehended in the university, not to mention that some of them will be leaders and decision-makers in society. As part of training engineering practices in the field of energy conservation, campuses could be living labs where students may learn, test and apply new solutions. In addition, considering that university campuses may also be a benchmark to local communities, they play a part in promoting sustainability through socially responsible actions. In this context, Thomashow (2014) presents a detailed comprehensive approach to how a sustainable campus may become the paradigm for a local community, how the campus should be and how to achieve this drive.

The application of a sustainable campus practice varies according to the interpretation of what a sustainable campus is. Several realities have been developed in various campuses around the world, as shown by Velazquez et al. (2006) who state that universities should define their own concept of sustainable university. Empirical data of descriptive information is shown in sustainability initiatives from 80 higher educational institutions and offers a definition of a sustainable university. The definition may be built upon one or more sustainability cornerstones: environmental, economic and social, depending on the university teaching area and the suitability to the mission statement that governs each institution.

As a consequence, various models and approaches to achieving campus sustainability have been proposed and implemented. Beyond the necessary clear vision of a sustainable campus for the university, there are two major factors which affect the success of the models proposed and may strongly prevent them from achieving better results in campus sustainability. On the one hand, financial constraints have hit higher education institutions and, on the other hand, every year lots of new students start to use the university campuses and, therefore, continuous awareness actions are needed in order to maintain energy conservation behaviours. In addition, individual sustainability initiatives carried out by university researchers and faculty are of a great value, but these will tend not to have a significant effect on global campus sustainability performance figures, if detached from the core operations of the campus.

After a review of the subject, Alshuwaikhat and Abubakar (2008) stated that there is a need for a professional and consistent environmental management approach to reducing the consumption of resources and the negative impacts of the various campus operations, to promote campus sustainability.

Most actions for increasing sustainability in university campuses are focused on reducing energy and water consumption. As also revealed by Velazquez et al. (2006), conservation measures in the use of these resources are the most applied around the world.

With a system dynamics modelling approach, Faghihi et al. (2015) showed that a sustainable campus programme based on the implementation of energy conservation measures that generate savings to fund energy efficiency measures, has shown the best performance with a modest initial capital investment, when results are measured by the total energy saved in the long run (360 months), and as long as conservation efforts are kept during the period. The university can develop this model autonomously without borrowing funds or engaging the services of an energy service company (ESCo). Programmes with higher initial capital investment, for example funded by borrowed money, show better results in the short run. Nevertheless, this scheme may not be suitable considering current capital constraints in universities. As pointed out in the paper, the returns of energy savings, if invested in non-sustainability projects can be a serious setback in the full success of the sustainability programme.

In 2011, IST carried out an effective sustainability policy at university level with the creation of two interdepartmental structures, the Environmental Sciences and Engineering Platform and the IST Energy Initiative (IST-EI), which were primarily responsible for the "Sustainable Campus at Técnico" project in order to implement tangible actions in the campus everyday life.

Since then, and with the full support of IST's governing bodies, the energy and water consumption policy has been accomplished by a team that coordinates and serves as the liaison between the various stakeholders: faculty, staff, students and other campus users.

Recently, sustainability has been incorporated in the Strategic Plan of IST (IST 2015), as one of the main action lines related to the focus area of infrastructure: "*Increase in sustainability of the IST campuses: IST will continue to develop the efficient use of resources, namely water and energy, based on system monitoring and technical studies that have been systematically carried out. This practice, which has already been recognized internationally, began at the Alameda Campus and has been extended to the CTN and Taguspark campuses, aiming at improving IST's environmental performance and producing cost savings.*"

This work reports the most significant results of the "Sustainable Campus at Técnico-Lisbon" project. The paper is divided into five sections, including this Introduction. The following section presents the project and the third section describes the main actions carried out to achieve the proposed goals. Results are presented in the fourth section and the last section draws the main conclusions and provides an outlook of future work.

2 Sustainable Campus at Técnico-Lisbon

As the largest school of Engineering, Science and Technology, and Architecture in Portugal, Instituto Superior Técnico (IST) has more than eleven thousand students, half of them M.Sc. and Ph.D. students, 850 faculty and researchers, and five hundred administrative and technical staff, distributed in three campuses and two separate university dormitories in the Lisbon area.

The Alameda Campus is the largest and oldest of the current IST campuses. Between 2006 and 2010, the annual electricity consumption was around 14 GWh, with a 1 MW base load. The electrical energy consumption accounts for 95 % of the total energy costs in existing campus buildings and represents over three quarters of the total energy bill.

Located at the center of Lisbon, the campus has an area of one hundred thousand square meters. It comprises 26 independent buildings, as shown in Fig. 1, in which administrative activities, university education, research and development are carried out, as well as all other necessary support activities.

Different buildings host different engineering specialties, which also stand out for the various architectural styles of the 20th century. Buildings of the 1930s coexist with those erected in the early years of this century. This diversity may be related to an effective difference between the needs for usage of resources in

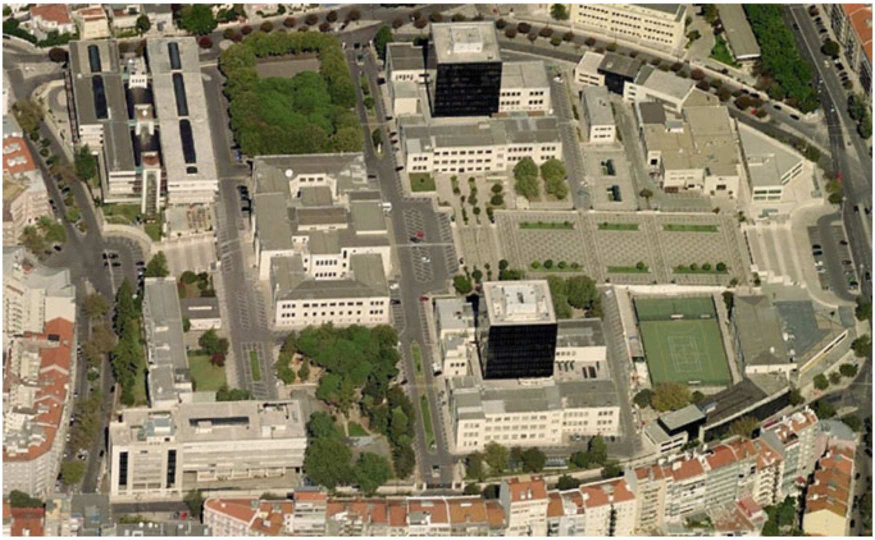


Fig. 1 The Alameda Campus of Técnico: aerial view

specific applications, far beyond the standard formulas for allocating consumption to buildings, though without abandoning them.

The "Sustainable Campus at Técnico" project was designed with the purpose of improving the overall energy efficiency in the facilities, while seeking a better energy performance and strengthening these skills throughout IST's community.

The general idea was that by increasing knowledge and awareness of campus users in fields related to their own resource consumption would be a very effective way to bring about improvements in efficient energy usage. Therefore, the option made was to put in place a project that involved the student and research community, leveraging the existing knowledge on energy efficiency and the implementation of a sustainable campus.

The first target of the project was to reduce electricity consumption on the Alameda Campus, with a strategic goal of achieving a significant decrease in the electric bill, bearing in mind the expected effective preservation in overall activity levels on campus.

The permanent operating team of the "Sustainable Campus at Técnico" project consists of three in-house people who work directly for the project.

3 Main Actions

The project started with a detailed energy audit for all of the campus buildings, which took the shape of an "Advanced" energy audit, also known as "Investment-Grade Audit". This involved a detailed quantification of energy usage through a comprehensive examination and analysis of equipment specifications and their operating conditions, characterized in extensive measurement campaigns. A specific working methodology exposed by Matos et al. (2014) was established to match the main goals of the detailed energy audit for each of the campus buildings. The accuracy of the estimated energy consumption profile, as obtained by these energy audits, basically depends on the continuous update of the survey data, and the accomplishment of new energy measurements, as a result of university campus dynamics, which is characterized by frequent modifications in laboratories and spaces for research fellows, new facilities and building renovation.

The results provide data not only in terms of total consumption, but also regarding usage and stand-by consumption. This allowed the base load of the electrical consumption profile to be considered and assigned to each energy usage. The leading objective was to decrease the campus base load by implementing simple and no-cost energy-conservation measures, like turning off equipment during inactive periods.

In order to maintain updated information on the energy consumption profile of all campus buildings, a computer application was developed by the project team. Among other features, this calculation tool estimates energy performance indicators, determines the disaggregation of energy consumptions in each building and allows the impact of energy conservation measures to be analysed.

The no-cost energy conservation measures included one general awareness campaign, and a specific campaign for the adoption of best practices, which involved building managers and other university personnel. Technical operations and maintenance staff were given guidelines regarding energy savings, whereas other campus staff was involved and encouraged to participate in energy and water conservation activities.

Energy conservation measures also included more stringent control routines of equipment schedules, the introduction of reduced activity periods with specific rules to avoid unnecessary energy and water consumption, a progressive centralization of computer servers and data centres in appropriate facilities and the control of individual or smaller HVAC systems, and a continuous real-time monitoring of energy and water consumption on the campus and of energy consumption in all campus buildings.

During the first year of the project two energy consumption monitoring platforms were installed on the Alameda Campus. One of the systems is called "EnergIST" and currently records and updates energy consumption in all campus buildings. It was developed in-house with the scientific support of an associated research centre and customized to the future sub-metering of building's energy equipment. Kuipers et al. (2015) describe the system and how it is deployed.

In the second year of the project, a commercial system was installed for monitoring the energy consumed by the HVAC equipment on the eight largest campus buildings, which account for 75 % of the total acclimatized area. This task was indirectly funded by the Portuguese government, and enables to separate the energy consumption which corresponds to the electric HVAC functions associated with the centralized acclimatization of the spaces from the total building energy consumption in real time.

Figure 2 shows how beneficial the coexistence of the two systems is, with the permanent record of the HVAC component disaggregated (below) from the total building consumption (above) in the South Tower on November 4, 2013.

In 2014 a water metering system was installed on the campus. The system allows real time water consumptions to be monitored in the three public utility supply points. The extension of the "EnergIST" to gas metering is now under final testing. In 2016 four gas smart meters will be installed in the public utility supply points.

These monitoring systems support the metrics to evaluate activity progress and are of vital importance because they offer real-time analysis of energy and water consumption, controlling and instructing immediate corrective and adjustment actions. They are also used for energy profile model adjustment obtained via energy audits and computer simulation model calibration.

Thermal computational models have been developed for all buildings on the Alameda campus. They constitute the current tools used to analyze the impact of proposed energy efficiency measures. As an example, a sun control window film was applied in both glazed towers of the campus, as a result of the energy savings estimates calculated by computational simulation (Fig. 3).

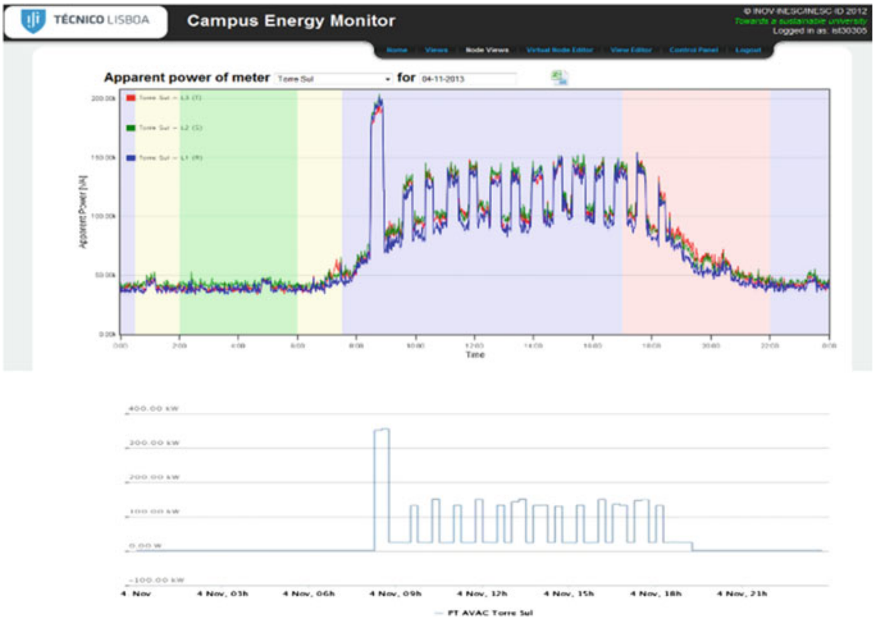


Fig. 2 Electric power monitoring systems at IST

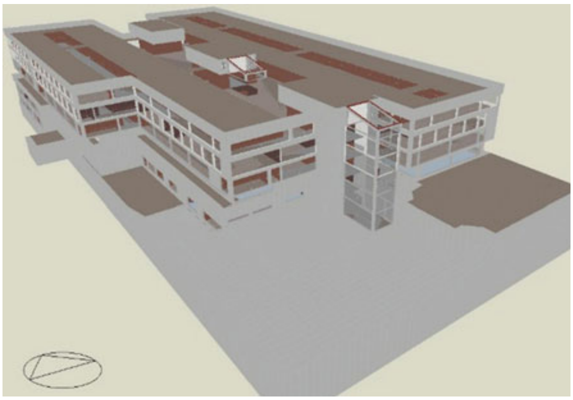


Fig. 3 Thermal computational model of the Civil Building on the Alameda Campus of IST

The whole IST community will have the opportunity to use these models in research activities, as virtual facilities for testing and studies, particularly as the models are validated by real and online energy consumption measurements. The impact on energy performance of each building with the proposed changes to buildings and systems may be valued, under the scope of an academic work. This effort is intended to promote the development of the Energy Efficiency Laboratory of IST, a living lab for teaching and research activities. This laboratory will support research activities carried out at the university in the areas of energy management, energy efficiency and sustainability, throughout the whole campus as an experimental environment.

During the project lifetime, about 20 M.Sc. theses were developed with the mentoring assistance of "Sustainable Campus at Técnico". The campus is used as an experimental facility in order to put in place a range of studies that promote the implementation of energy efficiency projects or the application of renewable energy sources.

The last two years of the project were also marked by the energy certification process of the Alameda campus according to Portuguese regulations and EU directives.

Energy certification allows universities to achieve general goals in terms of energy efficiency and gradual reduction of greenhouse gas emissions (Fig. 4).

Gaining certification visibly demonstrates a university's commitment to the future, since it has publicly presented a plan for improving campus energy efficiency. By implementing this plan, the Alameda Campus of IST will be allowed to improve its energy efficiency label.

Under the scope of the project, an annual spring university workshop has been organised since 2013 to promote the discussion of sustainability issues. Students and researchers are encouraged to present their sustainability works and talk about the interaction between academia and the community with a focus on how experiences in the university campus can be incorporated into the business sector, society or become a way of life for the new generations.

4 Results Achieved So Far

As described by Matos et al. (2014), a mathematical model was developed as a result of the energy audit carried out, which makes use of very detailed information regarding energy usage on the campus for estimating energy consumption in the campus buildings. The consumption model gives per building results in terms of total energy consumption, energy consumption profile by type of equipment, active and stand-by regimes, and type of space. The results also quantify the energy consumption of all technologies related to each type of equipment, as shown in Fig. 5 for lighting in the Civil Building. This is a very important outcome for evaluating energy efficiency measures based in retrofitting.

The energy consumption model developed in the energy audit was also used to analyze base load consumptions. The base load analysis provides the fraction of building annual energy consumption due to its permanent absorbed power. The permanent absorbed power profile assigned by type of equipment is also calculated.

The collected data led to the creation of a digital repository of energy-related information on the whole campus, in terms of building characteristics, occupancy levels, energy usage data and activity indexes, HVAC inventory, lighting, electric

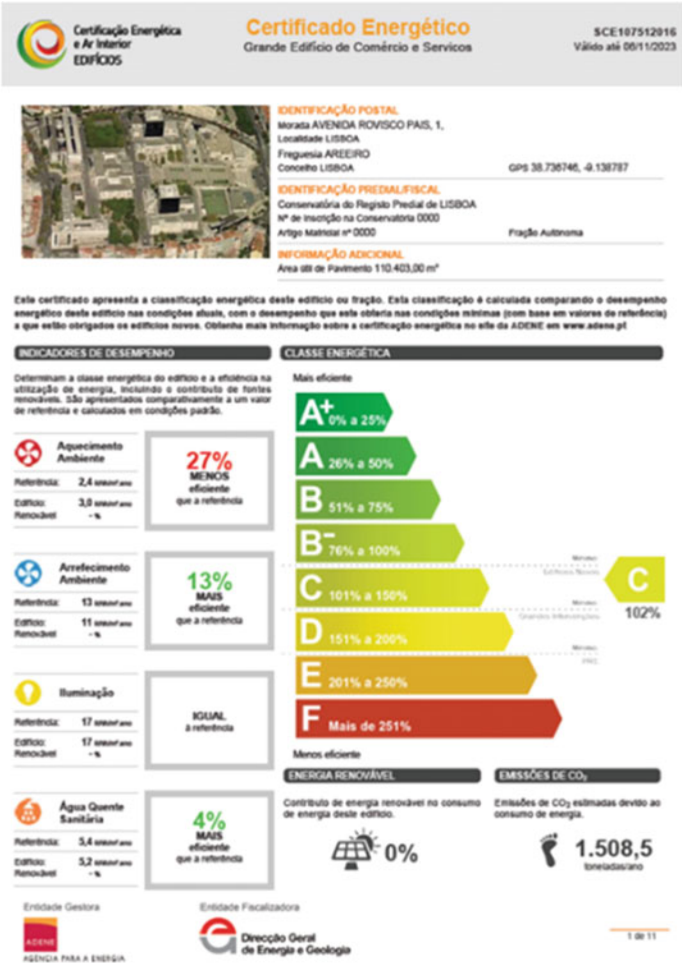


Fig. 4 SCE (2015) Energy Performance Certificate of the Alameda Campus

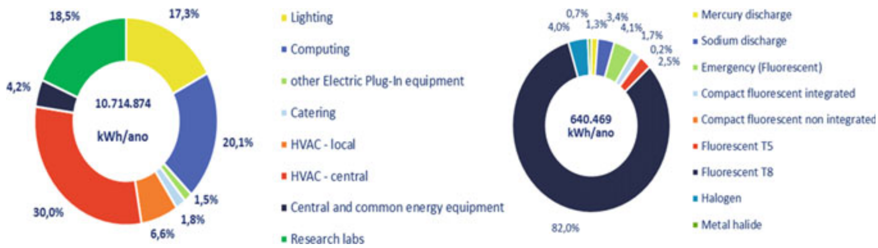


Fig. 5 Energy audit results (year 2013): the complete disaggregation of energy usage on the Alameda campus is shown *on the left*, excluding commercial concessions, losses and extraordinary events; the lighting usage by technology in Civil Building can be seen *on the right*

plug-in equipment, auxiliary and common systems, usual load factors, etc. This entire database is now available online to all campus stakeholders, including students and researchers, supported by members of faculty. Good and feasible ideas may well become measures to be implemented on campus, as long as implementation mechanisms are found.

Until now almost one hundred students, tutored by fourteen professors from different departments, have developed practical work on campus in energy efficiency. Seventeen of these works were Master Thesis as part of project activities and have been developed on the campus.

For example, Soares (2015) analyzed the possibility of placing photovoltaic panels on the available roofing of campus buildings and generate locally electric power to inject in the medium voltage ring grid of the Alameda campus, as prescribed by Portuguese legislation and related regulations for this type of projects. This study allowed one to conclude that the campus has a maximum available usable area of 4317 m^2, corresponding to an installed power capacity of 724 kW, which is able to fulfil the campus electric consumption needs for no more than 10 %. An ongoing Master Thesis has studied the possibility of equipping the campus swimming pool with a solar thermal system for pool and shower heated water. Thesis projects do effectively contribute to promote the development of solutions based on renewable energy sources, while constituting valuable learning experiences for students.

Due to the high investment and other costs to the university associated to the total replacement of the current system of the Civil Building (Fig. 3), studies have been developed to renovate or retrofit the acclimatization system of this building. This justified a previous analysis of the impact of choosing to replace only some of the individual system parts. Marçal et al. (2015) summarizes the work developed during his M.Sc. thesis programme to create a computational sub-model for testing.

Since early 2012, practical lessons have also been taught which relate to energy efficiency in the campus facilities and with a better usage of water on the campuses. In addition, the "Sustainable Campus at Técnico" project has directly cooperated with two European R&D projects where IST was involved and three other projects funded by the Portuguese government.

Energy audits, together with some academic works mentioned, have allowed energy efficiency measures to be characterized, which were classified in terms of feasibility, implementation difficulty and associated cost by investment classes.

One of the first energy efficiency measures analyzed in detail (Correia 2012) was the installation of window solar films in the glazed towers of the campus (Fig. 6). As a result, a 25 % reduction in cooling needs was expected, which globally corresponds to a 9 % decrease in electric power consumption in the building; before the installation, in 2012, the South Tower accounted for 15 % of the total electric power consumption of the campus; the payback expected for the investment is three years. In the following year the same measure was applied in the North Tower, which represented about 7 % of the campus power consumption in 2013. The implementation of this measure brings about additional benefits: a small extra reduction of the lighting consumption (indirect effect due to lower utilization of

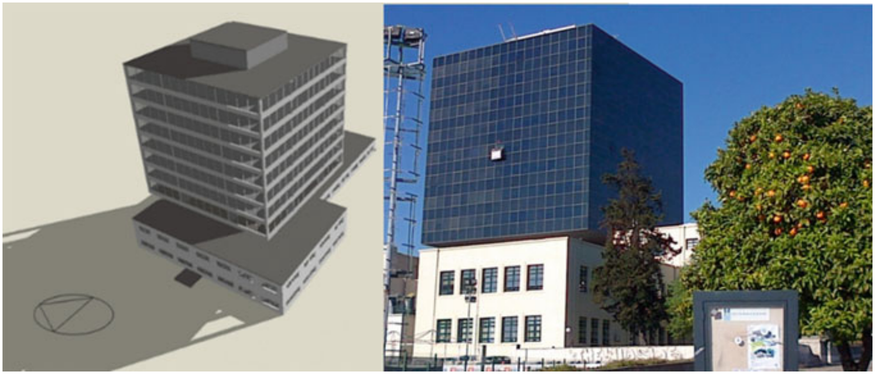


Fig. 6 South Tower of the Alameda campus: a thermal computational model is shown *on the left*, whereas it is possible to observe the final tasks of installing the solar film in glazed facades *on the right*

interior blinds as protection against glare); greater visual comfort; better function of the glazing.

Since mid-2014 the "Sustainable Campus at Técnico" project team, in cooperation with the Maintenance Division of IST have been implementing, to the extent that the university's investment capacity allows or whenever there is the need for replacement due to malfunctioning, a lighting retrofit programme in common areas of five of the largest campus buildings. Such programme generally includes the replacement of the existing T8 fluorescent lamps (about 80 % of the lighting solutions on the campus are based in T8 fluorescent lamps, as may be seen, for example, in Fig. 5, on the right) for lamps with LED technology.

A previous analysis of each particular case may give rise to a solution which includes the optimization of the sectoring of the electric circuit, applying occupancy sensors, and lighting sensors in some spaces where natural lighting has proven sufficient. As an example of a particular achievement accomplished with this programme, a solution with motion sensors and light fixtures which have two levels of luminance, i.e. 100 and 30 % with no movement, has been adopted in the hallways of the Interdisciplinary Building, because the building users want to avoid dark public spaces.

Such energy efficiency measures combined with operational changes with insignificant cost and the no-cost energy conservation measures stated in the previous section, resulted in a significant decrease in electricity consumption of the Alameda campus in 2012 and 2013. As expected, a smaller reduction has been achieved in the two last years but with evident persistent savings.

Although the concern about energy consumption dates from 2011, in line with the establishment of an effective sustainability policy at the university, the project officially started on the first day of 2012. The year 2011 was chosen as the baseline year of the "Sustainable Campus at Técnico" project.

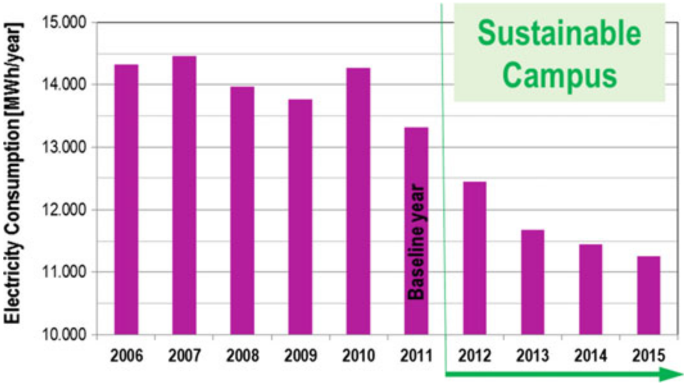


Fig. 7 Annual global electricity consumption in the last ten years on the Alameda Campus of IST and the years of the "Sustainable Campus at Técnico" project

By the end of 2015, a total reduction of 15.5 % in the electricity bill, in comparison with 2011, can be observed (Fig. 7). This was achieved without reducing any of the university activities, representing financial savings that exceed two hundred thousand Euros per year.

Despite the overall on-campus activity has remained constant throughout these years, and even despite an increase in 14 % of working hours of all staff since the last quarter of 2013, due to Portuguese regulations for Public Administration, there has been a significant decrease in electricity consumption, from 14 GWh/year to 11.2 GWh in the last year.

The increase in building occupancy, as a result of extended working hours would lead one to suppose a negative result in energy consumption. Nevertheless, despite an increase in the operating period of energy equipment derived from increased working hours (especially lighting, computing equipment, auxiliary and common systems, and multi-purpose equipment), the overall annual results have maintained the downward trend of energy consumption in that same year and in the following years. This fact demonstrates a certain resilience of the adopted energy management policy and sound results.

Energy conservation measures have been implemented on the basis of a step-by-step methodology. In the first year of the project, the top priority of energy management efforts was the evaluation of on-campus energy equipment which operated improperly or purposelessly. For example, energy system's operating hours were restricted during slack time when buildings are not occupied. Following the philosophy of having building systems with their operating time kept to a minimum, in the second year of the project, a more detailed analysis led to the implementation of rules, such as changing day-night time clock of central HVAC systems, during spring and fall seasons, to operate fewer daily hours, or turning off heating or cooling central systems some time before the end of occupancy period. All these measures have been analyzed on a case-by-case approach, and comfort conditions and user need fulfilment have been maintained.

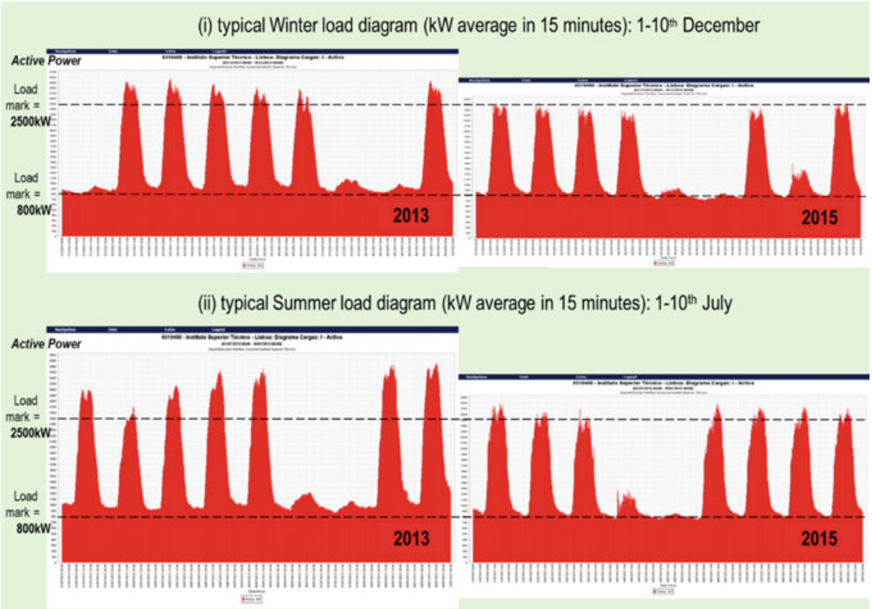


Fig. 8 Load diagrams as obtained from utility company; with annotations

During the third year of the project, 2014, and as the audits were being completed, energy management efforts were focused on reducing base loads, as well as peak loads, particularly in summer, with respect to the time of daily electricity bill rates.

The typical load diagram of the campus with a significant high base load clearly indicates that a major effort should be focus on this topic and the energy audits carried out have concentrated on understanding how the loads are allocated to different uses.

Figure 8 shows the savings obtained between 2013 and 2015 in winter (above) and summer (below). It is possible to observe that peaks are lower, which are also affected by milder temperatures observed last year. Nevertheless, the base load, which is not expected to reflect a significant influence on the weather conditions, fell below 850 kW during weekdays and below 800 kW during the weekends.

Recognizing the work done, the “Sustainable Campus at Técnico”, obtained the “International Energy Project of the Year 2014” award by the Association of Energy Engineers (AEE). The award was presented on October 1st, 2014, in Washington DC, during the 38th World Energy Engineering Congress (WEEC 2014), at the Washington Convention Center in Washington, D.C.

5 Conclusions and Future Work

The "Sustainable Campus at Técnico" project provided further motivation for a central policy to promote sustainability, and its success is due to the cooperation between the operational management staff of the IST, through integrated actions with the campus building managers, with the Maintenance Division of IST and the Construction Division of IST, and faculty and students, in a joint effort to reduce energy and water consumption.

The project has contributed to significantly reduce energy consumption on the Alameda campus of IST. The decrease in total electric energy consumption over the last four years was 15.5 % with no reduction of the university's total activity, which accounted for financial savings that exceeded two hundred thousand Euros per year.

Almost one hundred students have developed practical work on the campus and participated directly in the "Sustainable Campus at Técnico" project activities. About twenty M.Sc. Thesis have resulted from this practical work, and some ideas have already been implemented.

In the future, IST expects to implement programmes with broader scope and larger investment with returns up to 10 years with partners that demonstrate highly motivated and have financial capacity. These partnerships, which are attractive to IST both technically and financially, should also contribute to knowledge transfer initiatives between partner companies and the university, to the benefit of our engineering and architecture students.

References

Alshuwaikhat, H. M., & Abubakar, I. (2008). An integrated approach to achieving campus sustainability: Assessment of the current campus environmental management practices. *Journal of Cleaner Production, 16*, 1777–1785.

Correia, M. F. (2012). *Modelling energy consumption of Torre Sul of IST and definition of measures to reduce energy consumption*. M.Sc. Thesis, September 2012, Mestrado Integrado em Engenharia Mecânica, Instituto Superior Técnico, Lisboa, Portugal.

Faghihi, V., Hessami, A. R., & Ford, D. N. (2015). Sustainable campus improvement program design using energy efficiency and conservation. *Journal of Cleaner Production, 107*, 400–409.

IST. (2015). Instituto Superior Técnico, A School for the World – Strategic Plan, 2015.

Kuipers, M. B. W., Taveira, J. P., Nunes, M., & Matos, M. (2015). *EnergIST: An energy and targeting monitoring system*. IT4 Energy, April 27–28, Fundação Calouste Gulbenkian, Lisboa.

Marçal, G., Eça, L., & Matos, M. (2015). EnergyPlus simulator of the Civil Engineering Building of the IST Alameda Campus. Congresso de Métodos Numéricos em Engenharia 2015, Lisboa, 29 de Junho a 2 de Julho, APMTAC, Portugal, 2015.

Matos, M., Patrício, J., & Pereira, R. (2014). Energy audit methodology and base load analysis in Técnico-Lisboa, Universidade de Lisboa. PCEEE 2014: Eficiência Energética como Factor de Competitividade, 20 Junho 2014, Fundação Calouste Gulbenkian, Lisboa.

SCE. (2015). Certificado Energético – Grande Edifício de Comércio e Serviços, SCE107512016, ADENE, Portugal.

Soares, R. A. I. (2015). *Implementation study of renewable energies in IST Campuses: Alameda and Taguspark*. M.Sc. Thesis, March 2015, Mestrado Integrado em Engenharia Eletrotécnica e de Computadores, Instituto Superior Técnico, Lisboa, Portugal.
Thomashow, M. (2014). *The nine elements of a sustainable campus*. Cambridge, Massachusetts: The MIT Press.
Velazquez, L., Munguia, N., Platt, A., & Taddei, J. (2006). Sustainable University: What can be the matter? *Journal of Cleaner Production, 14*, 810–819.
WEEC. (2014). 2014 WEEC proceedings. 2014 World Energy Engineering Congress, October 1–3, 2014. Washington, DC: Walter E. Washington Convention Center.

Authors Biography

Professor Paulo Manuel Cadete Ferrão graduated in Mechanical Engineering (1985) from IST—Instituto Superior Tecnico of the Technical University of Lisbon. He earned a Master's degree in Heat Transfer and Conversion in 1988 and a Ph.D. and "habilitation" in Mechanical Engineering at IST in 1993 and 2004, respectively. He is the National Director of the MIT-Portugal Program and he is also the coordinator of the Sustainable Energy Systems Ph.D. program at IST. He is a Full Professor at IST. He has been active in the area of "Sustainable Cities", where he published a book at MIT-Press on "Sustainable Urban Systems" co-authored with John Fernandez from MIT. He has authored three books and co-authored two other books in the area of Industrial Ecology. He is the author of more than eighty papers published in journals and book chapters and has leaded more than thirty scientific projects in the areas of Energy Efficiency and Industrial Ecology.

Engineer Mário Miguel Franco Marques de Matos graduated in Mechanical Engineering (1993) from IST—Instituto Superior Técnico of the Technical University of Lisbon. In 1998, he obtained his Master's degree in Mechanical Engineering—Energy. He became Research & Development Director in Atecnic, HVAC manufacturing company. He was responsible for the Energy Unit of ISQ—Instituto de Soldadura e Qualidade. He has been active in the area of Energy Management. He has a certification from DGEG, Directorate-General for Energy and Geology, to carry out Energy Audits in industry. He is also certified as a CMVP (Certified Measurement & Verification Professional) by EVO, Efficiency Valuation Organization/AEE—The Association of Energy Engineers. He is the technical coordinator of Post-graduation programmes in the area of Energy by ISQ—Instituto de Soldadura e Qualidade, in Oeiras. He currently serves as Advisor of the Management Board of IST—Instituto Superior Técnico for the area of Energy Efficiency.

Unipoli Green—Four Universities Working Together for Sustainability

Eveliina Asikainen, Sannamari Hellman, Lotta Parjanen, Marika Puputti, Saana Raatikainen and Marjut Schroderus

Abstract

This paper introduces the Finnish context for promoting sustainable development in higher education and describes and analyzes the development of cooperation in Tampere, Finland: its benefits, challenges and limitations. The expectations for universities to promote sustainable development are rising while the resources for sustainability work are scarce. In Tampere there are four universities, Police University College, Tampere University of Applied Science, Tampere University of Technology and University of Tampere, educating and employing over 40,000 people. Promoting sustainability is in different phases at each of these universities. The coordinators of sustainable development in these universities met in spring 2014 and agreed on information sharing and cooperation in the form of concrete events and thematic days. This initiative was supported by the existence of the universities' cooperation platform UNIPOLI. Later the cooperation has found three major fields: (1) awareness raising, (2) sharing information and influencing management and (3) curriculum development. Possibility of sharing knowledge and experiences and building a community has enabled more efficient actions in all these fields, but the vague mandate of network has caused confusion and hindered realization of some ideas.

E. Asikainen (✉)
Department of Industrial Engineering, Tampere University of Applied Sciences, Kuntokatu 3, 33520 Tampere, Finland
e-mail: eveliina.asikainen@tamk.fi

S. Hellman · M. Schroderus
Tampere University of Technology, Tampere, Finland

L. Parjanen
Police University College, Tampere, Finland

M. Puputti · S. Raatikainen
University of Tampere, Tampere, Finland

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_16

Keywords
Sustainability · Higher education institutions · Networking

1 Introduction

The universities' and other higher education institutions' role as vanguards of sustainable development is stated in many international declarations (see e.g. Leal Filho 2010; Amaral et al. 2015). In Finland new goals for Education for Sustainable Development were set in the beginning of the UN Decade of Education for Sustainable Development (Melén-Paaso 2006). The sustainability coordinators of universities are agents of change who are expected to promote broad and strategic goals, turn them into practises or teaching modules and challenge prevailing ways of working. The typical obstacles hindering successful sustainability work characterized by Velasquez et al. (2005) are part of the Finnish sustainable development promotion reality. There is very little supporting staff or peer colleagues with whom one could share the challenges in integrating the sustainability aspects into education or into daily activities at campus.

According to Kurland (2011) a strong in-campus network is essential in promotion of SD. We, as authors, fully agree, but want to emphasize the importance of local inter-institutional cooperation in empowering the critical change agents. Four HEIs located in Tampere, Finland, have tackled this situation by networking. The Finnish higher education system consists of two complementary sectors: polytechnics (universities of applied sciences) and universities (Ministry of Education and Culture 2016). Two members of the network are universities (University of Tampere and Tampere University of Technology) and two polytechnics (Tampere University of Applied Sciences and The Police University College). The higher education institutions' collaboration network in Tampere, UNIPOLI, also participates in the cooperation.

The paper aims at critically reflecting the development of a cooperation network of professionals working to promote SD in universities located in same city. The paper starts with a general description of policies steering SD in higher education in Finland, which is essential in order to understand the context. Also the backgrounds, policies and developments before 2014 when the cooperation started are shortly reviewed. The main part of the paper describes how the cooperation between universities works in practise and assesses the achievements. As reflections of inter-institutional cooperation are rare, this example can provide useful insights which can help others in organizing inter-institution cooperation.

2 Methods

The paper is based on document analysis and authors' experiences and reflections. National policy papers and reviews on the development of SD in Finland are used to describe the context in which Finnish HEIs work in SD promotion. The networking institutions' policy papers and in-house documents are used to present local developments and describe the working environment of the network. Finally the authors' experiences and reflections of the cooperation are used to evaluate the success and development needs of the cooperation. Reflections of cooperation were collected and written down in two UNIPOLI Green meetings during autumn 2016. Quotes used in the paper are from these discussions.

3 Sustainable Development and Higher Education in Finland

In Finland discussion about environmental education and education for sustainable development (ESD) in higher education began after Rio 1992 Summit and was followed by Agenda 21 for the Baltic Sea Region (Baltic 21 1998). In the early years of SD promotion education was considered as a cross-sectoral target but it was soon noticed that this was not enough to promote ESD. Therefore an Agenda 21 adapted for Education in the Baltic Sea Region was accepted in 2002 (Baltic 21E 2002). The same year the United Nations General Assembly declared the Decade of Education for Sustainable Development 2005–2014 (DESD). In Finland these two programs were joined into one action plan called *Sustainable Development in education; Implementation of Baltic 21E Programme and Finnish strategy for the Decade of Education for Sustainable Development (2005–2014)* (Melén-Paaso 2006).

This action plan set objects or recommendations for all levels of education in Finland. For the universities and the universities of applied sciences there were separate recommendations. The universities were supposed to (1) integrate sustainable development into their education, research and strategies, (2) create partnerships with universities in developing countries and (3) implement environmental action plans that also include goals for sustainable consumption. The universities of applied sciences were expected to consider sustainable development in their strategies, daily practises, curriculum development, research and development, and in international cooperation (Melén-Paaso 2006, 62–64).

Partnerships with universities in developing countries were enhanced when eleven Finnish universities decided to promote international development as a part of their international strategies in 2002. An inter-university network UniPID was started also in response to the Johannesburg Summit on Sustainable Development. The UniPID network provides the strategic coordination to build ties and increase cooperation between Finnish universities in the field of international development cooperation (UniPID 2011). University of Tampere and Tampere University of Technology are members of UniPID.

In the early years of DESD the Ministry of Education promoted research projects about ESD in higher education and supported implementation (e.g. Kaivola and Rohweder, 2006, 2007). With the support of these research projects and the national ESD resource center in Åbo Akademi University a Finnish SD Forum in Higher Education was started in 2008 (BUP 2016). This Forum aims at supporting especially university teachers in integrating SD into higher education. It received some funding during its early years, but later no resources have been allocated for coordination. Therefore the Forum works only if some university is active in summoning a meeting or organizing a seminar. The Forum has a mailing list which enables information sharing between the HEIs. During the years the Forum has collectively tried to influence on the Ministry of Education to add some elements encouraging universities to promote SD into governmental steering.

The Rectors' Conference of Finnish Universities of Applied Sciences (ARENE) responded to the Ministry's guidelines by ordering a report on developing indicators of SD for Finnish Universities of Applied Sciences. This report states that work on SD in Universities of Applied Sciences should focus on (1) sustainable management and organization culture, (2) sustainable teaching and learning and (3) research and development activities promoting sustainability (Virtanen et al. 2008). This report has served well in promoting sustainability work in UASes, also in TAMK.

In 2011–2013 a project called Education for Sustainable Development in Academia in the Nordic countries (ESDAN) was carried out by three Nordic universities: Novia University of Applied Sciences in Finland, University of Gävle in Sweden and University of Roskilde in Denmark. Purpose of the project was to help Nordic HEIs to integrate SD into education (Holm 2014). The special focus was to use the already existing quality systems in the integration work.

All together 11 HEIs took part the project in Sweden, Denmark and Finland. The project resulted in developing a process model to enhance ESD in HEIs with management systems. Also relevant sustainability aspects in the degree programs were identified. The experiences and results were disseminated in four seminars (Ibid. 139–151).

The historical review shows that there is a political consensus on the importance of sustainable development in higher education in Finland and the Ministry of Education has supported many publications on ESD (see e.g. Kaivola and Rohweder 2007). However, resources to support universities in their sustainability work and inclusion of sustainability into the steering mechanisms of the HEIs have been missing. This has resulted in great variation in the implementation and goals of SD work in Finnish universities. Some have adopted environmental management systems (Holm 2014) or used their green campus developments in marketing (LUT 2016). Some are still in the beginning of their sustainability work. This indicates that without clear objects and steering measures, sustainability work is easily overlooked. As an answer to the situation the HEIs in Tampere started creating local network.

4 Local Background

Each participating HEI in Tampere has its own area of expertise and they work in close collaboration "to form one of Finland's most attractive and multidisciplinary consortia for education, research and regional development" (TAMK 2016c). TAMK, TUT, UTA and the Police University College comprise a dynamic and a regionally and globally connected network of expertise.

University of Tampere (UTA) is a culturally-committed higher education institution with the social mission of educating visionaries who understand the world and change it (UTA 2016b). UTA is committed to creating a sustainable world in which all people have an equal right to well-being. UTA is Finland's biggest provider of higher education in social and administrative sciences, and has strong profile in the multidisciplinary research and education on society and health. UTA offers 26 Degree Programs in Finnish and 12 Master's Degree Programs in English. It is a community of 15,000 students and 2000 employees and operates on three campuses in Tampere (UTA 2016d).

Tampere University of Technology (TUT) explores new avenues of research and education in the fields of engineering. The University acknowledges its responsibility for the future by maintaining high ethical standards in all its endeavors for the benefit of the environment, Finnish society and humanity as a whole (TUT 2016b). TUT campus is a community on 10,500 undergraduate and postgraduate students and nearly 2000 employees. There are 7 Bachelor's Programs (one in English), 21 Master's Program's (eight in English) and 5 Doctoral Studies Programs in technology and architecture. TUT's leading-edge fields of research are signal processing, optics and photonics, intelligent machines, bio-modelling and the built environment (TUT 2016a).

Tampere University of Applied Sciences (TAMK) merged from two Universities of applied sciences in 2010. Engineering, business and health care form the backbone of TAMK, but the degree programs cover a diverse range of professions from music to business, forestry and media. About 10,000 degree students and 700 staff members study and work in over 40 degree programs—seven of which are in English—on seven campuses in Tampere region. Sustainable development is one of the values stated in the strategy of TAMK, and TAMK is committed in making Finnish education competence available worldwide (TAMK 2016a).

The Police University College (POLAMK) is the only institute in Finland training police officers. It is responsible for police training recruitment, for selection of students for diploma and advanced programs, for organizing diploma and advanced studies, for further training given in the training institute and for research and development in the police field (POLAMK 2016). The Police University College employs approximately 200 people, over half of whom are teaching staff. Broad social responsibility is one of the objectives expressed in the strategy and in the police officer's oath (Police of Finland 2016).

UTA, TUT and TAMK signed Unipoli Tampere Agreement in 2006. Police University College joined the Unipoli Tampere network in 2013. The agreement aims at establishing closer ties between the institutions, supporting efficient use of resources and promoting the city's development into an international hub of expertise. Unipoli collaboration focuses on four strategic areas: education, internationalization, research and development, and support services, which are all related to sustainable development (Unipoli 2015). In autumn 2014 UTA, TUT and TAMK started discussion on even deeper cooperation and possibly merging the universities in near future. This process was named as Tampere3 (TAMK 2016c).

5 Sustainability Work in the Universities

The four universities have developed SD promotion independently and thus arrived in varying solutions in organizing sustainability work. Also the weight given to SD varies. Features describing the each university's SD work have been compiled in Table 1 and are discussed next.

In UTA and TUT SD promotion started in 1996 and in TAMK 2003. Origins of SD work in the universities vary. UTA had an active group of students, who started Ecocampus project aiming at diminishing environmental impacts of the university (UTA 2013). In TAMK the original driving force was the Degree Program of Environmental Engineering, which used the polytechnic as living lab in Environmental Management and organized many awareness raising campaigns for other students and staff (TAMK 2012). In TUT the initiative came from an active teacher and in POLAMK from the management.

The commitment of top management plays a vital role in SD promotion. In UTA, TAMK and TUT there is strategic commitment to SD (TAMK 2016b; TUT 2016b; UTA 2016b). TAMK has also given a public commitment in sustainability (Commitement2050 2016). One common feature of organizing SD work in these universities is having an official advisory group to support SD coordinator's work. However, the resources allocated to, and organization of sustainability work, varies greatly in the universities (see Table 1). Whereas in UTA there is a full-time environmental coordinator, in TAMK sustainability work is led by a lecturer along with her teaching duties. TUT has an environmental expert, but there are no resources for wider sustainability work. In POLAMK the organization of SD work is still taking shape.

In UTA, TAMK and TUT sustainability work is steered with sustainability action plan (e.g. TAMK 2012; UTA 2012), but there are remarkable differences in the scope, accuracy and ways of monitoring of the plans. The UTA and TUT action plans include indicators to monitor development and are published yearly (see e.g. UTA 2016c).

Promoting ESD started in UTA in 2007 with a survey for the university faculties resulting in a report (Lindroos and Raatikainen 2007) and a special course on "*Climate change from the social sciences point of view*". In 2011–2013 UTA participated in the Nordic ESDAN project and with the support of the project ESD was integrated in all the UTA curricula. Courses which contain sustainability aspects are now labelled in the curricula. Since 2013 a multidisciplinary sustainable development study module has been open to all UTA students (UTA 2015).

TUT's new strategy for 2016–2020 states that the technological expertise of students is built on a solid foundation in mathematics and natural sciences. Students learn to understand the importance of technology in addressing the challenges of SD. One of TUT's four high-quality research fields is energy and eco-efficiency—circular economy for a greener tomorrow. The integration of environmental requirements and SD issues in teaching is—and has been—done throughout research and degree programs. An excellent specimen is the work which has been going on consistently at the Department of Chemistry and Bioengineering on International Water Education and Training Activities in Eastern Africa, Namibia, the Baltic-Nordic region and Eastern Europe. TUT holds a Unesco Chair in Sustainable Water Services (TUT 2016b; UNESCO 2012).

Degree studies in TAMK and POLAMK lead mainly to professional bachelor degrees. In these degrees ESD is embedded in the professional competences. For instance in the education of policemen social sustainability is considered as the most important dimension of sustainability as the task of the police is to uphold social order and juridical system, maintain public order and safety and prevent and investigate crime. The values and good practises underlying police operations are incorporated into the ethical oath of the police (Police of Finland 2016). Inclusion of sustainability in the value bases of all bachelor degrees was surveyed in TAMK in 2012. At least one dimension of sustainability was mentioned in the value bases of 68 % of the degrees (TAMK 2012).

All universities have taken actions to reduce the environmental impacts of university buildings, facilities and everyday actions. UTA has been a pioneer in using fair trade products in university catering and was the first university in Finland to achieve the Fairtrade University title in 2009. That requires university to promote fair trade, take into consideration its responsibility for the community and acknowledge its social liability and ethical values when making acquisitions (UTA 2016a).

6 The UNIPOLI Green Network at Work

The UNIPOLI Green network was launched in the spring of 2014. The environmental coordinator of UTA convened a meeting to discuss the situation of sustainable development in the universities operating in Tampere. The meeting resulted in a decision of establishing a loose cooperation network to help sharing ideas, promote sustainability campaigns and gain new momentum for the sustainability work. The network started to call itself UNIPOLI Green referring to the co-operation platform of the HEIs.

For the time being the UNIPOLI Green group has mainly had resources for electronic communication. The members of the network meet approximately monthly during the semesters and the meetings are hosted alternately by member universities. All members are able to raise issues on the agenda and there is no chairperson in the network. The agenda for the next meeting is agreed in the end of each meeting and in e-mail discussions. Summaries of meetings are distributed to all members of the network. Matters discussed in the meetings and promoted together can be divided into three major themes (1) promoting awareness of sustainable development practices at the campus and in the community (2) sharing information and influencing management to make commitments on sustainability and (3) developing curricula.

6.1 Promoting Awareness

Events promoting sports on campuses and sustainable commuting (e.g. bicycling) are an established part of UNIPOLI cooperation under UNIPOLI Sport. Therefore combining SD with sports promotion proved easy. The first UNIPOLI Green activity was together with the Fairtrade City Tampere-project to donate Fair Trade balls for UNIPOLI Sport (universities joint sport services) and the student unions of all universities.

After this first experience of arranging activities together, organizing and informing together about activities soon became an important branch of action in UNIPOLI Green. So far the common campaigns include tips for energy saving distributed in all universities during the National Energy Saving Week 2014, Fair Trade Treasure Hunt in the National Fair Trade Week 2014 and 2015 and arranging and informing about Earth Hour activities in 2015 and 2016. Arranging fair trade activities revealed that the fair trade idea was quite poorly known among the students of TAMK. Jointly organized and promoted Earth Hour activities gained publicity in the local media.

As a part of promoting sustainable lifestyles the members of UNIPOLI Green have recognized the need for effective communication on campuses. UNIPOLI Green's solution for this was to establish a character contest in the fall of 2014. The contest was open for students and staff of all universities and it resulted in thirteen proposals. The winning character was called "Nipoli" referring to nagging—but not that badly nagging—with the person looking like a senior lecturer. According to the description of the character, "Nipoli" is more like a house elf—a tiny creature reminding everybody about the importance of sustainability in the daily actions (Picture 1). The UNIPOLI Green group was very satisfied with this character and ordered some cartoon with special messages from the artist. This character is used UNIPOLI Green's online ads.

Table 1 Comparison of sustainability work in UNIPOLI Green Universities

University	University of Tampere (UTA)	Tampere University of Technology (TUT)	Tampere University of Applied Sciences (TAMK)	Police University College (POLAMK)
University profile	Research oriented: Bachelor's, Master's and Doctoral degrees	Technological, Research Oriented: Bachelor's, Master's and Doctoral degrees	Professionally oriented Bachelor's and Master's degrees	Professionally oriented Bachelor's and Master's degrees
Students and staff	15,000/2000	10,500/2000	10,000/700	1000/200
Origin of SD work and starting point	Student activism on environmental impacts, 1996	An active lecturer, 1996	D.P. in Environmental Engineering, 2003	Management, 2014
Commitment in SD	Strategic	Strategic	Commitment 2050	Strategic (social sustainability)
Organization of SD	Full time coordinator (since 2006) in facilities management, steering group appointed by rector (since 2007)	Environmental specialist (since 2009) in facilities management, no special resource in SD	Group for SD, work lead by teaching staff, real estate management cooperates	No special resource in SD
Reporting	Yearly, indicators are set	Yearly in a report together with safety issues	Yearly reporting developing through commitment 2050	
SD in urriculum development	Systematically checked and marked in curricula since 2013	Not systematically organized	Part of curriculum update 2016	Not systematically organized
SD related contents	Multidisciplinary SD study module (emphasis on social sustainability), Global Health and Development Program	Part of professional studies in most programs, emphasis on ecological and economical sustainability	Part of professional studies in most programs, ecological, social and/or economic sustainability	Social sustainability part of professional growth

(continued)

Table 1 (continued)

University	University of Tampere (UTA)	Tampere University of Technology (TUT)	Tampere University of Applied Sciences (TAMK)	Police University College (POLAMK)
SD in real estate management and construction	In cooperation with the real estate owners, e.g. new BREEAM certified building	In cooperation with real estate owners, e.g. new BREEAM certified building	Own buildings, Energy-Efficiency Agreement: goals for diminishing use of energy, student projects	Operates in facilities provided by real estate owners committed to sustainable development
Awareness raising	Trough sustainability guide, cooperation with students, university staff and stakeholders	Through cooperation with students, university staff and stakeholders	Through student projects, cooperation with stakeholders an and University FB profile	Social sustainability is integrated into Finnish police organisation by legislation and approach
SD and research, development and innovation	Networks for researchers interested in SD interested researchers in international development and SD	Technologies promoting environmental sustainability International Water Education	Technologies promoting sustainability. Sanitation and sustainable tourism projects in developing countries	

Originally UNIPOLI Green sook wider use of the character, but this was hindered by objection coming from the university services and communications departments of some universities. Firstly they have expressed concerns that using this character widely would disturb the aesthetics of university interior. Secondly it has proven very difficult to find more permanent campaign topics which could be agreed by all universities until UNIPOLI Green's mandate is not sufficient.

6.2 Sharing Information and Influencing Management

The top management's commitment to promote sustainability is of vital importance for successful SD promotion. This is a clear message from the success stories of building sustainable universities like Chalmers in Sweden (Holmberg et al. 2012) or Novia in Finland (Holm 2014). UNIPOLI Green helps all participating universities in influencing top management by providing a platform for sharing and evaluating national and international developments and discussing possible directions of actions.

For example in spring 2014, when the Finnish Ministry of Environment launched a public pledge campaign "Commitment 2050" (Ministry of the Environment

2015), UNIPOLI Green soon discussed this possibility for making a stronger statement on sustainability in the HEIs of Tampere. It was suggested that the universities would make a shared commitment to sustainability and UNIPOLI Green members discussed this option with the top managements. The initiative was not successful. Tracking exact reasons is difficult, but clearly timing was unfortunate. The economic situation of universities was difficult and UTA, TUT and TAMK started Tampere3 process possibly heading to merger. This took the top management's attention. However, the "Commitment 2050" was taken on the agenda in two of the universities. TAMK joined the commitment in October 2015 and the process is going on in UTA (Asikainen 2015; Commitment 2050 2016).

When the merger process started, UNIPOLI Green discussed its threats and possibilities for SD in the campuses. The members of the network have actively raised up SD issues in all possible forums, discussed together about the developments in each university and made initiatives. So far this has resulted in establishing an official working group to coordinate ESD in Tampere3 process. The mandate of this group is limited, but still it proves that the unofficial cooperation has been able to bring SD part of the agenda of the merger process at least in the shape of ESD. This work is discussed more in the next chapter.

Affecting top management is not easy, but a larger group can help in formulating initiatives in such a way that they realize at least partially. UNIPOLI Green has also been able to convince the top management about the importance of SD in the Tampere3 process.

6.3 Curriculum Development

Each university has its own curricula and curriculum development processes. UNIPOLI Green's interest in curriculum development is in providing as wide as possible range of sustainability studies open for all students in the member universities.

In UNIPOLI Green, UTA is the pioneer in curriculum development as it took part in the Nordic ESDAN project during 2011–2013 (Holm 2014). In UTA a special SD label was added to the curricula. Some of those SD labelled courses that were open to all students were chosen to form a SD study module. This multidisciplinary study module is open for all the students of UTA (UTA 2015). The experiences of UTA have helped in convincing the TAMK management about the benefits and importance of ESD and organizing ESD curriculum development work. Renewed curricula with more emphasis on ESD are introduced in September 2016. The need for more transparent expression of sustainability issues has been raised also in POLAMK.

In spring 2015 UNIPOLI Green members from UTA, TUT and TAMK raised the matter of joint sustainable development studies in various discussions arranged as part of Tampere3 process. The purpose of these statements and remarks was to make vice-rectors conscious of the special opportunity the universities have. Contacting the vice-rectors proved effective. In October 2015 a group was appointed to find and select courses which could make up a joint study module of SD for the students of UTA, TAMK and TUT. The draft of this study module was presented in December 2015 and it is based on the existing SD study module of UTA arranged around three main themes: environment and society, responsible business and entrepreneurship, and health and global development (UTA 2015). TUT and TAMK widen the perspectives to technology and sustainable use of natural resources. Most challenging part of this work has been identifying suitable courses bearing in mind that the students' backgrounds can vary greatly. Another challenge is that UTA and TUT are more research oriented universities, whereas TAMK and POLAMK have professional education orientation.

7 Achievements, Challenges and Aspirations

This section discusses the experiences of UNIPOLI Green group on inter-institutional cooperation in promoting SD. The section is based on discussions of the group members i.e. the authors.

In the case of Tampere, the universities have made strategic commitments to promote sustainability. Nevertheless there are profound differences in organizing the practical work and in allocating resources into sustainability work. The people responsible for SD are in all these universities quite solitary and feel the lack of collegial discussion in their work.

This is probably the most important reason why networking is experienced as meaningful, effective and rewarding. It offers platform for continuous improving and learning from each other, which encourages everyday work. As the SD coordinator of UTA described in one discussion: "*If you suggest something at work, it comes back to you and you'll have to do it yourself. Here you can find somebody to do at least part of it. And you also get the feeling that your work helps others. It spreads to other universities*". This has been true for example in the case of spreading fair trade awareness through joint campaigns and in starting the joint SD study module work.

The representative of the Police College University has stated quite clearly that learning from other universities experiences has been most helpful in deciding how to proceed in arranging SD work. "*It is also good to hear that it has not been easy to get started anywhere - and you can always come here and let the steam out*". Also other members of the group have mentioned this supportive, encouraging and motivating dimension of UNIPOLI Green.

Among the participating institutions UTA has the longest, best established and resourced tradition of sustainability work. Other participants have benefited from UTA's experience for example by learning about wider national and international networks. This helps using resources allocated in SD more effectively. Also writing this paper has been a very revealing learning experience on the history of Finnish HEIs and SD networks for those who have only short experience in SD work.

One clear benefit mentioned by the participants is professional heterogeneity. The coordinators from UTA and TUT come from university services (facilities management) and the coordinators of TAMK and POLAMK have teaching-related positions. Also the members have various academic backgrounds: engineering, environmental policy, ecology and education. As the backgrounds and expertises on sustainability work differ, many questions rise during meetings. "*Having to explain helps you organize your thoughts and takes you further in your own work*", comments the coordinator of TUT. This way UNIPOLI Green helps spreading information inside HEIs and covering all areas of SD work: education, research and everyday actions.

The examples above demonstrate that the solitary work of SD coordinators can be boosted by collegial inspiration. A strong in-campus network would be ideal for that (Kurland 2011), but our experience is that a local inter-institutional network can also prove beneficial. UNIPOLI Green has offered this and thus catalyzed SD work. It has also given more weight on the SD work and helped influencing on the top management.

The voluntary network has also met its limitations. As the group does not have formal status and has only very limited budget, it is often dependent on the university services' or communications departments' will to take ideas forward or implement them. This was clearly noticed in the case of trying to launch the common character for communicating SD more effectively on campuses. Finding common understanding about the ways of using the character as part of communications has proven very difficult.

8 Concluding Remarks

In this paper we have described voluntary cooperation for sustainable development between four Finnish HEIs located in the same city. Our conclusion is that local inter-institutional cooperation can facilitate and strengthen SD promotion in the HEIs joining the network. According to our experiences the mechanisms contributing to this are based in the power of group. A peer group of professionals sharing same aspirations, interests and problems helps otherwise solitary working professionals share their problems, knowledge and experiences, be credited and share ideas. This opportunity is missing from the daily working life of sustainability coordinators at least in most Finnish universities. The coordinator may have an advisory committee or working group that supports the work, but often his or her role in the actual lobbying and promotion work is to convince others and advocate new ideas.

Furthermore, our experiences indicate that during a great change process, like the ongoing merger in three higher education instutions of Tampere, voluntary cooperation between HEIs helps keeping sustainability aspects on the agenda. When the same message comes repeatedly from all universities it cannot easily be left unattended. This way the UNIPOLI Green network was able to start preparations for sustainable development study module for open for students from all universities in Tampere.

Voluntary inter-institutional network does, however, have its limitations. At least in our case they are related to unclear mandate and position of the group. However, the benefits of networking outweigh the difficulties: awareness raising campaigns are more visible and creative, management takes commonly addressed initiatives or ideas already tested in one university more seriously than completely new thoughts. And finally, sustainability coordinators have found a new working community, which motivates their work.

Thus inter-institutional networking speeds up adoption of new, more sustainable practices, which is the ultimate mission of promoting SD in universities. Based on our experiences, we recommend local collegial collaboration between educational institutions for all SD promotion professionals.

References

Amaral, L. P., Martins, N., & Gouveia, J. B. (2015). Quest for a sustainable university: A review. *International Journal of Sustainability in Higher Education, 16*(2), 155–172.

Asikainen, E. (2015). *We want to commit to Sustainable Development* (in Finnish). Blog post. http://tamk-blogi.tamk.fi/tahdomme-sitoutua-kestavaan-kehitykseen. Last accessed January 29, 2016.

Baltic 21. (1998). *An Agenda 21 for the Baltic Sea Region*. http://www.un.org/esa/agenda21/natlinfo/action/baltic.htm. Last accessed January 29, 2016.

Baltic 21E. (2002). *An Agenda 21 for education in the Baltic Sea Region—Baltic 21E*. Baltic 21 Series No/1/2002. http://www.hu2.se/hu2old/Baltic21E.pdf. Last accessed January 15, 2016.

BUP. (2016). *About Keke forum* (in Finnish). http://www.bup.fi/index.php/keke-foorum/about-keke-forum. Last accessed January 15, 2016.

Commitment 2050. (2016). *Tampere University of Applied Science's Commitment*. https://commitment2050.fi/commitment/tampere-university-of-applied-sciences-society-s-commitment-to-sustainable-development. Last accessed January 23, 2016.

Holm, T. (2014). *Enabling change in universities: Enhancing education for sustainable development with tools for quality assurance*. Annales Universitatis Turkuensis. AII 289. Academic Dissertation.

Holmberg, J., Lundqvist, U., Svanström, M., & Arehag, M. (2012). The university and transformation towards sustainability. *International Journal of Sustainability in Higher Education*, *13*(3), 219–231.

Kaivola, T., & Rohweder, L. (Eds.) (2006). Korkeakouluopetus kestäväksi. Opas YK:n kestävää kehitystä edistävän koulutuksen vuosikymmentä varten. Opetusministeriön julkaisuja 2006:4 (in Finnish).

Kaivola, T., & Rohweder, L. (Eds.) (2007). *Towards Sustainable Development in Higher Education—Reflections and education for global responsibility—Finnish perspectives*. Publications of the Ministry of Education 2007:6.

Kurland, N. B. (2011). Evolution of a campus sustainability network: A case study in organizational change. *International Journal of Sustainability in Higher Education, 12*(4), 395–429.

Leal Filho, W. (2010). Teaching Sustainable Development at university level: Current trends and future needs. *Journal of Baltic Sea Education, 9*(4), 273–284.

Lindroos, S., & Raatikainen, S. (2007). Kestävää kehitystä edistävä opetus Tampereen yliopistossa. [Education for Sustainable Development in the University of Tampere]. Tampereen yliopisto. Tampere 2007.
LUT. (2016). *Lappeenranta University of Technology*. Frontpage. http://www.lut.fi/web/en/. Last accessed January 15, 2016.
Melén-Paaso, M. (2006). *Sustainable development in education. Implementation of Baltic 21E programme and Finnish strategy for the Decade of Education for Sustainable Development (2005–2014).* Reports of the Ministry of Education, Finland 2006:7 (in Finnish).
Ministry of Education and Culture. (2016). Education system in Finland. http://www.minedu.fi/OPM/Koulutus/koulutusjaerjestelmae/?lang=en. Last accessed January 15, 2016.
Ministry of the Environment. (2015). *Society's commitment to sustainable development*. http://www.ym.fi/en-US/The_environment/Sustainable_development/Societys_commitment_to_sustainability. Last accessed January 29, 2016.
POLAMK. (2016). *About the University College*. http://www.polamk.fi/. Last accessed April 2, 2016.
Police of Finland. (2016). *Ethical oath for police officers*. http://www.poliisi.fi/finnish_police/ethical_oath_for_police_officers. Last accessed January 15, 2016.
TAMK. (2012). *Sustainable Development Action Plan for TAMK* (in Finnish). Tampere: TAMK.
TAMK. (2016a). *Introducing TAMK*. http://www.tamk.fi/web/tamken/introducing-tamk. Last accessed April 3, 2016.
TAMK. (2016b). *Strategy*. http://www.tamk.fi/web/tamken/strategy#Mission. Last accessed April 2, 2016.
TAMK. (2016c). *Tampere3*. http://www.tamk.fi/web/tamken/tampere3. Last accessed April 1, 2016.
TUT. (2016a). *Facts and figures*. http://www.tut.fi/en/about-tut/facts-and-figures/index.htm. Last accessed April 3, 2016.
TUT. (2016b). *Strategy*. http://www.tut.fi/en/about-tut/strategy/index.htm. Last accessed April 1, 2016.
UNESCO. (2012). *UNESCO Chair in Sustainable Water Services*. http://www.unesco.org/en/university-twinning-and-networking/access-by-region/europe-and-north-america/finland/unesco-chair-in-sustainable-water-services-973/. Last accessed April 2, 2016.
UniPID. (2011). *Finnish University Partnership for International Development*. http://www.unipid.fi/en/page/6/finnish_university_partnership_for_international_development_unipid/. Last accessed January 30, 2016.
Unipoli. (2015). *Unipoli Tampere—Study and work in the Tampere Region.* http://study.unipolitampere.fi/. Last accessed January 29, 2016.
UTA. (2012). *The University of Tampere Sustainable Development Action Plan (SDAP 2012–2015).* http://www.uta.fi/ekokampus/en/program/SDAP_University_2012.pdf
UTA. (2013). *History of Ecocampus* (in Finnish). http://www.uta.fi/ekokampus/esittely.html. Last accessed April 3, 2016.
UTA. (2015). *Sustainable Development study module*. https://www10.uta.fi/opas/opintoKokonaisuus.htm?rid=10651&uiLang=en&lang=en&lvv=2015. Last accessed April 2, 2016.
UTA. (2016a). *Fairtrade University.* http://www.uta.fi/ekokampus/en/fairtrade.html. Last accessed January 28, 2016.
UTA. (2016b). *Sustainable development at the University of Tampere*. http://www.uta.fi/ekokampus/en/index/UTA%20Sustainability%20Report%202014.pdf. Last accessed April 2, 2016.
UTA. (2016c). *Towards a New University. Strategy of the University of Tampere 2016–2020.* http://www.uta.fi/esittely/strategia/index/strategia.pdf. Last accessed April 1, 2016.
UTA. (2016d). *University in nutshell*. http://www.uta.fi/english/about/nutshell.html. Accessed April 3, 2016.

Velazquez, L., Munguia, N., & Sanchez, M. (2005). Deterring sustainability in higher education institutions. *International Journal of Sustainability in Higher Education, 6*(4), 383–391.
Virtanen, A., Rohweder, L., & Sinkko, A. (2008). Kestävä kehitys ammattikorkeakouluissa – kehittämisen ja mittaamisen indikaattorit. [Sustainable Development in Universities of Applied Sciences – Indicators for Development and Assessment, in Finnish]. ARENEn julkaisuja.

Author Biographies

Eveliina Asikainen works as senior lecturer forestry and chairs the working group for sustainable development in Tampere University of Applied Sciences. She is M.Sc. in biology and Doctor of Administration in Environmental Policy.

Sannamari Hellman holds M.Sc. in Technology, graduated in Environmental engineering and Biotechnology. Her background is in research but she has worked as an environmental specialist at TUT since 2009.

Lotta Parjanen serves as senior inspector in the Police University College. When she was head of the student services, she founded group for sustainable development in Police University College. She holds M.Sc. in education.

Marika Puputti works as a head of student services in the Police University college of Finland. She has a M.Sc. in environmental sciences from Kuopio University (University of Eastern Finland). She is also a qualified information specialist.

Saana Raatikainen is a Master in Administration and graduated in Environmental Policy in 2003. She has worked as an environmental coordinator at UTA since 2001. She has also completed a study program in Administration and Management in Higher Education.

Marjut Schroderus was Unipoli Project Manager responsible for collaboration network coordination of four local higher education institutes, Police University College, Tampere University of Applied Sciences, Tampere University of Technology and University of Tampere until 30th June 2016. She has a background working in various administrative tasks in Universities and working in co-operation between academia and public sector. She holds a M. Sc. (Admin. Sc., public law) from the University of Tampere.

Prerequisites for the Sustainability of Municipalities in Rio Grande do Sul—Brazil: A Project to Foster Sustainable Development

Luciana Londero Brandli, Amanda Lange Salvia, Marcos Antonio Leite Frandoloso and Walter Leal Filho

Abstract

There has been a long-lasting debate about the sustainability of cities at the national and international levels, which goes back 30 years or so ago. By virtue of the undeniable growth of the world population and its consequences, the growth of cities has been a matter of great research interest and relevance across the world. Thus, the complexity of current environmental, social and economic demands induces the three levels of government, civil society and the private sector to take a new stance. This paper presents the preliminary results of the research project "Prerequisites for the sustainability of municipalities in Rio Grande do Sul—Brazil". In particular, this article highlights the role of the universities involved in a process of partnership and cooperation network linking the University of Passo Fundo, the Federal University of Santa Maria, the Federal University of Rio Grande do Sul in Brazil, and also the Hamburg University of Applied Sciences, in Germany. A discussion was held on the current status of cities in Rio Grande do Sul, based on sustainable development indicators, in addition to the identification and dissemination of measures and

L.L. Brandli (✉)
University of Passo Fundo, PPGeng Campus I, Passo Fundo, RS 99052-900, Brazil
e-mail: brandli@upf.br

A.L. Salvia · M.A.L. Frandoloso
School of Engineering and Architecture, University of Passo Fundo, Campus I, Passo Fundo, RS 99052-900, Brazil
e-mail: amandasalvia@gmail.com

M.A.L. Frandoloso
e-mail: frandoloso@upf.br

W.L. Filho
Hamburg University of Applied Sciences, Lohbrügger Kirchstr. 65, 21033 Hamburg, Germany
e-mail: walter.leal@haw-hamburg.de

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_17

best practices on sustainable techniques applicable to the three municipalities as regards solid waste, transport and mobility, energy, urban planning and education for sustainability. As a result, the present research highlights the commitment of universities to developing skills for implementation of sustainability and improvement of the quality of life in the project regions.

Keywords
Sustainable development · Indicators · Best practices · Communities · Universities

1 Introduction

Universities are an arena for an integrated and comprehensive discussion about themes relative to sustainability. Not only from a theoretical point of view, but especially in practical terms, universities allow the analysis of current characteristics as well as actual changes in the context where they are situated. According to Thomashow (2014, p. 2), they are the best place "to conduct environmental research, to develop curricular approaches, to construct policy mechanisms, to convene multi-sector collaborations, and to implement sustainable solutions". The author also highlighted the legacy of knowledge generated within the academic community (students, faculty, staff and administrators), leading to a shift in awareness through the relationship between knowledge, commitment and action.

Hoeger (2007, p. 13) stated that academic institutions have a role in "promoting internal knowledge transfer and social interaction to strategies that foster urban life or dynamic integration with an existing urban context". According to her, without exception, their main goal is to create an environment that can best nurture the dynamic synergies needed to create sustainable research centers and outreach programs dealing with knowledge and learning. They could be incubators of innovation that can flexibly respond to the rapidly changing demands of the knowledge society.

However, such knowledge and initiatives, indispensably, should be connected with local and regional realities. Partnership with the community and multidisciplinary participation allow universities to share their expertise, and look into their work in a broader perspective of collaborative research projects.

This vision of outreach programs is implicit in the definition of the Social and Environmental Development Policy of the University of Passo Fundo, approved in 2013. This way, its commitment to the local and regional community is expressed in the terms of this policy: "The University of Passo Fundo, with a view to improving the quality of life in its several campi as well as generating and sharing knowledge and technologies with the community, establishes guiding principles in order to achieve sustainable development, promote environmental education, comply with the current legislation, seek continuous performance improvement and integrate the environmental perspective into teaching, research and extension activities" (Dalmolin and Moretto 2014, our translation).

In specific areas of research such as in urban studies, both governments and academic communities must consider sustainability as a priority for cities. According to Yalcin (2014), the concept of the city has changed in recent times and now includes management processes that tend to bring about changes and increasingly implement sustainability techniques in addition to establishing mechanisms to make such techniques feasible. This makes it possible to combine the development of the territory with preservation for future generations. In this context, urban planning is another factor associated with the idea of developing more intelligent and sustainable cities, and it is undoubtedly the most economical and efficient way to recover and preserve urban space (IPPUC 2014).

Acselrad (1999, p. 83) states that convergence between local urban sustainability and global sustainability is often seen as a political simplifier, because at the local level, political authorities and those responsible for the effects of negative actions are clearly identifiable. As a result, it may be more feasible to implement local plans and awareness campaigns as well as search for actors engaged in projects aimed at achieving changes in this direction. In a study performed in four Swedish municipalities, Jörby (2002) established that the development of appropriate natural resource management at the local level is very important, so as to make cities more sustainable.

In order to characterize best practices, or rather, classify them, the Best Practices Program of the United National Centre for Human Settlements (HABITAT) identified urban policies and actions that may be effective in improving living conditions in cities. These "Best Practices", according to Hernández Aja (2001), rather than a term to determine the experiences that can be considered as the best imaginable performance on a given territory, may also qualify experiences that entail a change in forms and processes and be the reason for a positive change in traditional methods.

When the term "Best Practices" is used, the criteria established by HABITAT, according to Hernández (2001), should include: (a) Impact: proving that a given practice produces tangible improvements in the living conditions of people in any of the proposed subject areas; (b) Partnership: in order to handle the complexity of problems, the only way to ensure multidimensionality is through collaboration between entities in different spheres; (c) Sustainability: promotion of long-lasting changes, with effective results in decision-making processes. In Brazil, there is a program called "sustainable cities" from federal government, that offers a platform that serves as an agenda for sustainability, integrating the social, environmental, economic, political and cultural aspects and address the different areas of public management in 12 themes. Each of them are associated indicators and national and international benchmarks (Sustainable Cities Program 2015).

The project "Prerequisites for the sustainability of municipalities in Rio Grande do Sul (PRESUST-RS)" is focused on this subject, precisely, with research and discussion about local actions and practices that will improve people's quality of life. The project was created with the aim of spreading these sustainable practices and making the local community aware of the importance of its participation, given that sustainable development has been more of a concept than an actual practice. The aims of the project are:

(a) to investigate the extent to which a set of urban issues are present in the samples cities
(b) to list the prerequisites needed to allow cities to become more sustainable
(c) to identify ways to promote sustainable practices in the participant cities and beyond

PRESUST-RS is the result of a partnership between three universities in Rio Grande do Sul and one in Germany. The University of Passo Fundo (UPF), the Federal University of Santa Maria (UFSM), the Federal University of Rio Grande do Sul (UFRGS) and the Hamburg University of Applied Sciences (HAW) work together on the project, which has been operative since the beginning of 2015. The main objective is to investigate the prerequisites for cities to become more sustainable, thus seeking to stimulate local and/or regional measures that are appropriate to the specific requirements of the state of Rio Grande do Sul.

The aim of this paper is to show the methodology of PRESUST-RS, as well as the findings until now.

2 Research Methodology

The Project has been developed in partnership with three Brazilians universities and with the collaboration of the Hamburg University of Applied Sciences in Germany. The team consists of 14 teachers and 15 students (undergraduate and post graduate levels). The methodology of the research has been developed in several stages that build upon each other:

(i) **Definition of the cities of the study**: The project is focused in state of Rio Grande do Sul, south of Brazil. Figure 1 shows the cities that are being researched in depth. The cities were chosen based in their geographic importance to the region into account and the location of the cities: Passo Fundo, Santa Maria and Porto Alegre.
(ii) **Definition of work packages (sustainability thematic areas)**: The thematic areas were chosen considering issues related to challenges in infrastructure and sustainable cities: solid waste, urban mobility, energy (matrix and efficiency), urban planning, and education for sustainability. Table 1 shows the various thematic areas of the project.
(iii) **Indicators—search for existing indicators and practices in each sustainability thematic area**: The indicators were chosen based on their relevance and availability in each municipality. According ISO (2014) cities

Fig. 1 Study location and meetings

Table 1 Definition of thematic areas

Thematic areas for sustainability	Scope
Solid waste	This topic deals with urban waste management and efficient consumption
Urban mobility	This topic focused on the improvement of transport systems, promoting sustainable **mobility** choices
Energy matrix	This topic analyzes energy supply in the state of Rio Grande do Sul as regards its energy matrix and opportunities for increased sustainability
Energy efficiency	This topic deals with the energy efficiency in the cities, including the discussion on buildings and on infrastructure
Urban planning	This topic is focused on improving the welfare of people and their communities, by balance of new development and essential services, environmental protection and sustainability in the cities

need indicators to measure their performance, and it shall be consistent or comparable over time or across. Table 2 shows the indicators.

(iv) **Development of a website and a Fan page platform and promotion material**: This stage had the aim to divulge the project, as well, to work as a

Table 2 Indicators used in this project

Solid waste	Urban mobility	Energy matrix	Energy efficiency	Urban planning
Waste generation per capita	Length of dedicated cycle lanes	Domestic primary energy supply by source	Total electrical energy consumption per capita	Green area index
Reported domestic waste collection coverage for the total population	Length of dedicated bus lanes	Share of renewable energy sources in primary energy supply	Total electrical energy consumption	Green cover index
Reported domestic waste collection coverage for the urban population	Modal split	Domestic electricity supply by source	Percentage increase rate of total electrical energy consumption (2007/2012)	Urban public spaces
Coverage of direct (door to door) domestic waste collection for the urban population	Accessible bus fleet	Share of renewable energy sources in electricity supply	Electrical energy consumption by sector	Reserves/Protected areas
Existence of recyclable waste collection	Traffic accidents	Final energy consumption by sector	Total number of consumers	Resident population
Coverage of recyclable waste collection (door to door) for the urban population	Traffic death rate	Share of renewable energy sources by sector consumption	Electrical energy consumption by sector consumer unit	Governance in Public Administration—Management Plans
Recovery of recyclable materials compared with the total amount of solid waste	Motor vehicle deaths		Percentage of households with electrical energy supplied by the distribution company	
Recovery of recyclable materials per capita compared with the urban population	Bicycle deaths		Percentage of households with street lighting	
Existence of sanitary landfills	Motorcycle deaths		Residential electricity tariff	

(continued)

Table 2 (continued)

Solid waste	Urban mobility	Energy matrix	Energy efficiency	Urban planning
Percentage of solid waste in the city that is disposed of in a sanitary landfill	Traffic deaths		Consumption percentage of electrical energy generated from renewable sources	
Income of recyclable waste pickers included in the municipal selective collection system	Traffic accidents			
Cost of urban solid waste management in relation to the total municipal budget				
Cost of municipal solid waste management (per capita)				
Revenue collected for waste management services (per capita)				
Existence of municipal plan of integrated solid waste management				

link between the group and the community; (www.presust.com.br and https://www.facebook.com/PreSust/), design of publicity material, as a flyer, portfolio and gifts was also elaborated.

(v) **A survey for practices and sustainable models related to the thematic areas**. This topic looks for sustainable solutions, innovations and insights from other cities in Brazil or in other countries, related to each thematic area.

(vi) **Definition of the Best Practices applicable to each local reality**. The sustainable solutions are assessed in terms of economic feasibility, environmental impact and social acceptability.

(vii) **Mobilization, awareness and dissemination**: Meetings and workshops with local groups, the public and stakeholders to discuss sustainability, problems and solutions in these municipalities (Fig. 2). This stage brings support for stage (vi).

(viii) **Preparation of interim reports and publication of material with the best practices selected to society.**

Fig. 2 Meetings with local groups and stakeholders

3 Preliminary Results

So far, the PRESUST-RS project developed stages (i), (ii), (iii) and (iv). Tables 3, 4, 5, 6 and 7 show the indicators obtained for each area. Table 3 shows the indicators of Solid Waste. They address economic, social and environmental issues of the cities, from quantitative results for generation and recycling to data on management plans and management costs. Table 4 shows the indicators of Transport and Mobility. These indicators reflect the quality of mobility in cities, by evaluating the use of modal transportation, investments in this sector and accidents.

Indicators of Energy are divided into energy sources and energy efficiency. The analysis of the energy matrix is made at the state level, since the power grid is interconnected nationally, hence it cannot be evaluated at the municipal level, as shown in Table 5. On the other hand, energy efficiency analysis can be made by municipality, with a focus on energy consumption and addressing the economic, social and environmental issues as the remaining axes. Table 6 shows the indicators of that area.

Finally, the Urban Planning addresses key issues for sustainability, such as the green cover ratio in the municipalities, the existence of spaces such as parks and squares and the existence of management plans. Table 7 shows the data collected for these indicators.

This initial stage of defining the indicators is essential for diagnosis, with data collection for each municipality. Moreover, it is also fundamental to all subsequent stages of the project, e.g., the search for practices or sustainable models. With this information, an assessment can be made of the local and regional applicability of good sustainable practices for further selection.

The diagnosis points out several issues to be discussed on sustainability in the municipalities. As for solid waste management, Passo Fundo fails to recover recyclable materials, but the city generates the least waste per capita. This city also showed negatively surprising results for mobility, particularly with regard to traffic accidents and the traffic-related death rate.

Table 3 Solid waste indicators

Indicators	Passo Fundo	Porto Alegre	Santa Maria	Unit
Waste generation per capita	220.83	277.40	240.90	kg/inhab./year
Reported domestic waste collection coverage for the total population	97.46	100	100	%
Reported domestic waste collection coverage for the urban population	100	100	100	%
Coverage of direct (door to door) domestic waste collection for the urban population	60	38.43	100	%
Existence of recyclable waste collection	Yes	Yes	Yes	–
Coverage of recyclable waste collection (door to door) for the urban population	36.94	100	38.43	%
Recovery of recyclable materials compared with the total amount of solid waste	0.26	2.23	4.02	%
Recovery of recyclable materials per capita compared with the urban population	3.77	9.98	9.91	kg/inhab./year
Existence of sanitary landfills	No	No	Yes	–
Percentage of solid waste in the city that is disposed of in a sanitary landfill	96.59	96.91	98.04	%
Percentage of solid waste in the city that is recycled	1.43	5.64	0.77	%
Inclusion of waste pickers in municipal selective collection systems	3.07	24.92	Unavailable	%
Income of recyclable waste pickers included in the municipal selective collection system	940.40	716.15	Unavailable	R$/month
Cost of urban solid waste management in relation to the total municipal budget	Unavailable	5.88	4.55	%
Cost of municipal solid waste management (per capita)	Unavailable	157.61	55.51	R$/inhab.
Revenue collected for waste management services (per capita)	15.75	90.44	20.18	R$/inhab.
Existence of Municipal Plan of Integrated Solid Waste Management	No	Yes	No	–
Existence of Municipal Sanitation Plan	Yes	Yes	Yes	–

Source Data from National Information System on Sanitation (2013), Passo Fundo Sanitation Plan (2014), Santa Maria Sanitation Plan (2013) and Plan of Integrated Solid Waste Management of Porto Alegre (2013)

Table 4 Transport and mobility indicators

Indicators		Passo Fundo	Porto Alegre	Santa Maria	Unit
Length of dedicated cycle lanes		6.00	24.45	6.90	km
Length of dedicated bus lanes		0	55.2	0	km
Modal split	Public transportation	Unavailable	30	24.7	%
	Motorized individual		26	47.2	
	Non-motorized		44	28.1	
Accessible bus fleet		34.78	58.69	Unavailable	%
Traffic accidents		204.5	132.5	Unavailable	Number of occurrences per 10,000 people
Traffic death rate		6.7	9.8	Unavailable	Number of occurrences per 10,000 people
Motor vehicle deaths		1.08	0.20	0.38	Number of occurrences per 10,000 people
Bicycle deaths		0.05	0.04	0.08	Number of occurrences per 10,000 people
Motorcycle deaths		0.92	0.41	0.50	Number of occurrences per 10,000 people
Traffic deaths		1.76	0.98	1.80	Number of occurrences per 10,000 people
Hit and run deaths		0.70	0.40	0.84	Number of occurrences per 10,000 people

Source Data from DATASUS (2014) and Departamento de Trânsito do Estado do Rio Grande do Sul (2014)

With regard to energy efficiency, according to the Electrical Energy Statistics Yearbook (Energy Research Enterprise 2014), the average per capita consumption in Rio Grande do Sul for the year 2012 was around 2500 kWh/inhab., and consumption in Passo Fundo is close to these figures. In addition, the evaluation of indicators for Passo Fundo shows that the three sectors (households, trade and industries) consume approximately the same amount of energy. However, when evaluating the consumption per consumer unit, it can be seen that there is high demand from industries. Another highlight of this area for the city of Passo Fundo is the high cost of the residential electricity tariff, which ultimately affects the social sustainability of the region.

Table 5 Energy indicators (energy matrix)

Indicators		Rio Grande do Sul	Unit
Domestic primary energy supply by source	Petroleum	57	%
	Coal	13	
	Natural gas	3	
	Firewood	10	
	Hydropower	9	
	Wind energy	1	
	Other renewable sources	7	
Share of renewable energy sources in primary energy supply		74	%
Domestic electricity supply by source	Hydropower plant	71	%
	Coal	22	
	Wind energy	7	
Share of renewable energy sources in electricity supply		77.5	%
Final energy consumption by sector	Industrial	22	%
	Residential	13	
	Transportation	45	
	Trade	4	
	Public	2	
	Agriculture and Livestock	10	
	Energy sector	4	
Share of renewable energy sources by sector consumption	Industrial	56	%
	Residential	64	
	Transportation	11	
	Agriculture and Livestock	95	

Source Data from Capeletto and Moura (2014)

As far as urban planning is concerned, Passo Fundo positively excels in terms of its green coverage ratio and amount of reserve areas or protected areas.

The state capital, Porto Alegre, shows better results for solid waste management in comparison to the other cities, but has the highest rate of waste generation per capita and the lowest rate of household garbage collection. Porto Alegre stands out in mobility, as there are more kilometers of dedicated cycle lanes and dedicated bus lanes, which are considered to be necessary in a big city.

The diagnosis of energy efficiency showed that while Passo Fundo has the highest electricity in the industrial sector, one of the largest consumers of electricity in Porto Alegre is the trade sector, pointing out sectors in which best practices of efficiency should be mainly focused. The evaluation of the urban planning in Porto Alegre shows that the capital city has a high green area index, and related to that, a high percentage of reserves or protected areas.

Table 6 Energy indicators (energy efficiency)

Indicators		Passo Fundo	Porto Alegre	Santa Maria	Unit
Total electrical energy consumption per capita		2422	2533	1941	kWh/inhab./year
Total electrical energy consumption		454,063	3,590,739	511,795	MWh
Percentage increase rate of total electrical energy consumption (2007/2012)		24.0	24.3	12.5	%
Electrical energy consumption by sector	Households	140,437	1,248,579	254,337	MWh
	Industries	115,898	361,124	49,648	
	Trade	111,922	1,590,952	128,769	
Total number of consumers		77,866	570,665	108,963	un.
Percentage increase rate of total number of consumers (2007/2012)		18.2	13.4	7.9	%
Number of consumers by sector	Households	69,004	488,362	98,419	un.
	Industries	529	4261	442	
	Trade	7722	76,233	6900	
Electrical energy consumption by sector consumer unit	Households	2035	2557	2584	kWh/consumer unit
	Industries	219,089	84,751	112,326	
	Trade	14,494	20,870	18,662	
Percentage of households with electrical energy supplied by the distribution company		99.6	99.3	99.0	%
Percentage of households with street lighting		90.9	90.4	86.6	%
Residential electricity tariff		0.42	0.34	0.32	R$/kWh
Consumption percentage of electrical energy generated from renewable sources		77.5	77.5	77.5	%

Source Data from Economics and Statistics Foundation (2012), The Brazilian Institute of Geography and Statistics (2010) and Brazilian Electricity Regulatory Agency (2012)

Santa Maria, among the municipalities under study, shows the best results of the assessment of solid waste, mainly as regards waste collection coverage rates and recovery of recyclables. Still, it can evolve with greater investment in recycling and recyclable waste collection. On the other hand, in terms of urban mobility, Santa Maria can seek greater incentive to public transportation in order to reduce the rate of preference for individual motorized transportation.

As for energy efficiency, Santa Maria stand out positively for having the smallest increase rate of electricity consumption in recent years, compared with the other municipalities. However, it is the municipality with the lowest rate of public lighting service, which implies that smallest increase rate can be related to deficiency in a service that should be serving the population in its totality

Table 7 Urban planning indicators

Indicators		Passo Fundo	Porto Alegre	Santa Maria	Unit
Green area index		0.97	44.62	0.59	m^2/inhab./year
Green cover index		14.63	8.02	7.2	%
Urban public spaces	Parks	1	9	1	un.
	Squares	17	316	51	
Reserves/Protected areas		6	32	16	%
Resident population	Urban	97.45	100	95.14	%
	Rural	2.55	0	4.86	
	Subnormal	1.09	13.68	5.13	
Governance in Public Administration—Management Plans	Master Plan	Yes	Yes	Yes	–
	Urban Mobility Plans	Under development	Yes	Yes	
	Municipal Councils	Yes	Yes	Yes	

Source Rocha and Werlang (2005), ObservaPoa (2010), Porto Alegre City Council (2015), Santa Maria City Council (2015), Passo Fundo City Council (2015), SOS Mata Atlantica (2013), The Brazilian Institute of Geography and Statistics (2010) and ONU HABITAT (2015)

In the diagnosis of urban planning, the city has the worst ratings for green area index and green cover, which is indicative of points for improvement.

The energy, with a focus on the energy matrix, shows that the primary energy domestic supply still has marked preference to non-renewable sources, such as crude oil; however, 77.5 % of the electricity supply comes from renewable sources, which is very positive for the state and for the country in terms of sustainability.

4 Conclusions

In a society that constantly changes its built environment and has exerted greater pressure on available resources, the creation of programs aimed at the sustainability of cities is of fundamental importance. As a result, research consolidates the commitment of universities to developing skills for implementation of sustainability and improvement of the quality of life in the region.

The results found so far show the subject areas demand more attention from the sustainable practices that will be suggested for each municipality or region.

As the present research is continued, based on the analysis of indicators, guidelines are being developed to suggest good practices in each of the thematic areas, in order to assist decision-making processes at different scales of operation, both in government bodies and in civil society. Thus, this outreach program plays a role in producing knowledge and practical experience for the communities involved with the three Brazilian universities under study. Additionally, it aims to promote an academic network of knowledge diffusion, commitment and concrete actions.

Although the PRESUST-RS project does not target the implementation of sustainable practices, it hopes to create and mobilise the necessary support for the diagnosis of towns and cities and awareness of practices that should be applied to the local community, and pursuit of education, information and understanding of the importance of this issue for life in society.

Acknowledgments The authors would like to thank Capes (Coordination for the Improvement of Higher Education Personnel) for financial support for this research through no. 88881.068119/2014-01.

References

Acselrad, H. (1999). Discursos da sustentabilidade urbana. R. B. Estudos Urbanos e Regionais. Nº1, May.

Brazilian Electricity Regulatory Agency. (2012). *Tarifas residenciais*. Available at: http://www.aneel.gov.br/area.cfm?idArea=493. Accessed December 20, 2015.

Brazilian Institute of Geography and Statistics. (2010). *Cidades*. Available at: http://www.cidades.ibge.gov.br/xtras/home.php. Accessed August 9, 2015.

Capeletto, G. J., & Moura, G. H. Z. (2014). *Energy Balance of the state of Rio Grande do Sul 2014: year 2013*. Porto Alegre: Grupo CEEE/Secretaria de Infra-Estrutura e Logística do Rio Grande do Sul.

Dalmolin, B. M., & Moretto, C. M. [Org.] (2014). *Política de responsabilidade social 2013/2016*. Passo Fundo: Ed. Universidade de Passo Fundo, Passo Fundo.

Datasus. (2014). *Informações de saúde*. Ministério da Saúde. Available at: http://tabnet.datasus.gov.br/cgi/deftohtm.exe?idb2000/c12.def. Accessed January 15, 2016.

Departamento de Trânsito do estado do Rio Grande do Sul. (2014). *Diagnóstico de 2014*. Available at: http://www.detran.rs.gov.br/conteudo/27441/diagnostico-de-2014. Accessed January 15, 2016.

Economics and Statistics Foundation. (2012). *Dados abertos*. Available at: http://dados.fee.tche.br/. Accessed May 10, 2015.

Energy Research Enterprise. (2014). *Anuário Estatístico de Energia Elétrica 2014: ano base 2013*. Ministério de Minas e Energia. Available at: http://www.epe.gov.br/AnuarioEstatisticodeEnergiaEletrica/Anu%C3%A1rio%20Estat%C3%ADstico%20de%20Energia%20El%C3%A9trica%202014.pdf. Accessed September 2, 2015.

Hernández Aja, A. (2001). *Informe sobre la evolución de las Buenas Prácticas Españolas y su relación con el cumplimiento del Programa Hábitat: introducción, Ciudades para un futuro más sostenible, Madrid.* Available at: http://habitat.aq.upm.es/evbpes/abpes_1.html. Accessed August 8, 2015.

Hoeger, K. (2007). Campus and the city—A joint venture? In K. Hoeger & K. Christiaanse (Eds.), *Campus and the city—Urban design for the knowledge society* (pp. 13–23). Zurich: gta Verlag, ETH Zurich.

IPPUC. Instituto de Pesquisa e Planejamento Urbano de Curitiba. (2014). *Sustentabilidade: Cidades Inteligentes e Criativas*. Curitiba: IPPUC. Available at: http://www.ippuc.org.br/mostrarpagina.php?pagina=262&idioma=1&liar=n%E3o. Accessed April 20, 2015.

International Organization for Standardization. (2014). ISO 37120:2014. Sustainable development of communities—Indicators for city services and quality of life (84 p.).

Jörby, S. A. (2002). Local Agenda 21 in four Swedish Municipalities: A tool towards sustainability. *Journal of Environmental Planning and Management*, *45*(2). doi:10.1080/09640560220116314
National Information System on Sanitation. (2013). *Banco de dados*. *Resíduos Sólidos*. Available at: http://www.snis.gov.br/. Accessed November 10, 2015.
ObservaPoa. (2010). *Indicators*. Available at: http://portoalegreemanalise.procempa.com.br/. Accessed August 10, 2015.
ONU HABITAT. (2015). *E-Governance and urban policy design.* Available at: http://unhabitat.org/books/e-governance-and-urban-policy-design-in-developing-countries/. Accessed August 10, 2015.
Passo Fundo City Council. (2015). *Secretaria do Meio Ambiente*. Available at: http://www.pmpf.rs.gov.br/secretaria.php?c=467. Accessed August 10, 2015.
Passo Fundo Sanitation Plan. (2014). *Relatório do Diagnóstico-Produto 2*. Available at: http://www.upf.br/pmsb/index.php. Accessed November 10, 2015.
Plan of Integrated Solid Waste Management of Porto Alegre. (2013). Available at: http://lproweb.procempa.com.br/pmpa/prefpoa/dmlu/usu_doc/pmgirs_porto_alegre_volume_2.pdf. Accessed November 10, 2015.
Porto Alegre City Council. (2015). *Parques e Praças*. Available at: http://www2.portoalegre.rs.gov.br/smam/default.php?p_secao=290. Accessed August 10, 2015.
Rocha, J. R., & Werlang, M. K. (2005). *Índice de cobertura vegetal em Santa Maria: o caso do Bairro Centro* (pp. 85–99). UFSM: Ciência e Natura.
Santa Maria City Council. (2015). *Secretaria do Meio Ambiente*. Available at: http://www.santamaria.rs.gov.br/ambiental/. Accessed August 10, 2015.
Santa Maria Sanitation Plan. (2013). *Volume IV – Resíduos Sólidos*. 2013. Available at: http://www.santamaria.rs.gov.br/docs/psa/psa_volume_IV.pdf. Accessed November 10, 2015.
SOS Mata Atlantica. (2013). *Atlas dos municípios da mata atlântica*. Available at: https://www.sosma.org.br/wp-content/uploads/2014/05/atlas_2012%202013_relatorio_tecnico_20141.pdf. Accessed August 10, 2015.
Sustainable Cities Program. (2015). http://www.cidadessustentaveis.org.br/institucional. Accessed March 24, 2016.
Thomashow, M. (2014). *The nine elements of a sustainable campus*. Cambridge, Massachusetts: MIT Press.
Yalcin, G. (2014). Urban activities in the view of the Sustainable Development. *Procedia Technology, Turkey*, (12), 566–571. Available at: http://www.sciencedirect.com/science/article/pii/S2212017313007159. Accessed March 20, 2014.

Authors Biography

Luciana Londero Brandli is graduated in Civil Engineering (1995), master's degree in Civil Engineering (1998) and Ph.D. in Production Engineering (2004). Pos Doctorial Research at Hamburg University of Applied Sciences (2014). She is currently Associate Professor at University of Passo Fundo, south of Brazil, working in the Master Program in Engineering and Environment. Her current research interests include sustainability in high education and green campus, environment management, management of urban infrastructure, sustainable cities and green buildings.

Amanda Lange Salvia is graduated in Environmental Engineering (2015) at Passo Fundo University. She is currently master student in Civil Engineering and Environment. Her current research interests include energy efficiency, sustainable cities and environment management.

Marcos Antonio Leite Frandoloso has a degree in Architecture and Urbanism at Federal University of Pelotas (1986), Master in Architecture at Federal University of Rio Grande do Sul (2001). Currently he is Ph.D. candidate at Universitat Politècnica de Catalunya, Barcelona, Spain, focusing on eco-efficiency and environmental management at universities. He has experience in Architecture and Urbanism with emphasis on building and environmental planning, acting on the following topics: energy efficiency, energy and environment, sustainable construction, bioclimatic architecture, architectural heritage, ecodesign and urban ecology.

Walter Leal Filho has a first class degree in Biology and a doctorate in environmental science (Ph.D.), having also completed a post-doctorate programme on environmental communication. He also has a higher doctorate (Dr. rer. nat habil.) in environmental information (D.Sc.), a D.Phil. in sustainable development and holds the titles of Doctor of Letters (D.L.), Doctor of Literature (D. Litt.) and Doctor of Education (D.Ed.) commensurate with his scientific performance and outputs translated by over 300 publications among books, book chapters and scientific papers.

A Decade of Earth in the Mix: A Bibliometric Analysis of Emergent Scholarly Research on Sustainability Education and Ecopsychology in Higher Education

Amanda Leetch and Marna Hauk

Abstract

As part of understanding methodological approaches which aim to integrate the topic of sustainability in the curriculum of universities, the intersection of ecopsychology with education for sustainable development marks an emergent methodological and curricular bridge. Using Bayesian probablistic modeling of related topics, called latent Dirichlet allocation, an analysis of theses and dissertations published since the advent of the UN Decade of Education for Sustainable Development revealed a substantial volume of higher education research regarding ecopsychology and sustainability education in higher education (using Proquest Database). Within that larger field, several hundred works existed at the intersection of ecopsychology and education for sustainable development/sustainability education. This research reported on findings from analyzing titles, abstracts and keywords of this data set of theses and dissertations to identify emergent trends in topics within the research scholarship. Initial findings indicated directions for viable inter- and transdisciplinary collaboration in order to extend and integrate the reach of sustainability education across the university curriculum. Research from the field suggested such inter- and transdisciplinary curricular approaches to the "wicked" problems of sustainability are requisite to cultivate the next generation of sustainability innovators and educators.

A. Leetch (✉)
Department of Education, Prescott College, Prescott, AZ, USA
e-mail: amanda.leetch@student.prescott.edu

M. Hauk
Department of Sustainability Education, Prescott College, Prescott, AZ, USA
e-mail: earthregenerative@gmail.com

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_18

Keywords
Sustainability education · Ecopsychology · Resilience · Latent dirichlet allocation · Bayesian network · Bibliometric analysis · Post-DESD sustainability education

1 Introduction

The present research was part of a larger state of the field analysis to investigate the growing convergence of education for sustainability and sustainable development and ecopsychology in higher education. This bibliometric inquiry developed a type of Bayesian network, known as a *latent Dirichlet allocation* (LDA) method (Blei et al. 2003), to uncover the thematic trends within the theses and dissertations that converge in these fields. It looked closely at the way these emergent trends indicate a transdisciplinary application of ecopsychology that could be mobilized as a curricular bridge to integrate sustainability throughout the academic curriculum.

In this paper we have discussed education for sustainability (EfS) and sustainability education (SE) within higher education, acknowledging the copious overlap with the discourses and concerns of education for sustainable development (ESD) in higher education.

1.1 Research Motivation

Education for sustainability is of critical importance to the present global moment. Global systems evidence increasingly complex and interrelated instability, seen in the seemingly intractable sustainability issues commonly referred to as *wicked problems*.

However, research indicates that environmentalism and sustainable development projects can exacerbate the tension between ecological and social justice, while failing to address the root-causes of these overlapping issues (Shoreman-Ouimet and Kopnina 2015). Without increased attention to the epistemological foundation of education for sustainable development, it is likely that the projects produced will continue the history of ecotraumatization and colonization by employing the same reductionist methods that created the multiplex problems sustainability disciplines are concerned with (Kahn and Humes 2009).

Ecopsychology is a fairly young discipline that could be integrated to support the epistemological evolution of environmental psychology with sustainability education. Ecopsychology can be differentiated from other psychologies of the natural environment by its focus on the holistic, embodied, and existential aspects of humans' connectedness and inter-being with the rest of nature and a characteristic therapeutic response to the emotional impacts of issues like species extinction or global climate change (Doherty 2011, para. 7).

Ecopsychology does not consider the individual identity to be a boundary of separation, but rather an emergent part of interrelated and overlapping living systems (Roszak 1995, p. 13; Buzzell and Chalquist 2009). It focuses holistically on the connection between human wellness and the health and wellness of earth systems across scales.

Integration of this ecopsychological orientation could serve as a curricular bridge to address the underlying assumptions that sometimes hinder the effectiveness of initiatives to weave education for sustainability across university curriculums. This research wondered whether inclusion of ecopsychology in sustainability education could improve student's capacity to address multiplex issues with complex and sophisticated problem solving, supporting their ability to manifest persistent hope and psychological resilience (Macy and Johnstone 2012). Transdisciplinary integration creates a conceptual context to invite conversations about education for sustainability and education for sustainable development into other departments in the university setting. This research will extrapolate how the research dissertations and theses at the convergence of ESD and ecopsychology represent this potential.

2 Informing Literatures

The literatures that grounded this research included the bodies of woven content and process scholarship in education for sustainability and sustainable development in higher education as well as research in ecopsychology.

2.1 Education for Sustainable Development and Sustainability Education in Higher Education

Education for sustainable development, and allied formulations such as sustainability education and education for sustainability, involves learning to engage with multiplex challenges involving complexity of definition, multiple stakeholders, and dynamic contexts that require multiple perspectives and creativity (Corcoran and Wals 2004, p. 88). Integrative approaches with academic-theoretical, experiential-pragmatic, and motivational-values dimensions of education for sustainability have been suggested to support transformative learning (Sipos et al. 2008). Wals and Blewitt conducted a review of "third-wave" sustainability education programs, those with the purpose "to re-orient teaching, learning, research and university–community relationships in such a way that sustainability becomes an emergent property of its core activities" (Wals and Blewitt 2010, p. 56). Social learning has been identified as critical to addressing these "wicked" or multiplex problems in sustainability education (Wals 2007). Ecological imagination and sustainability creativities are also required in sustainability in higher education approaches (Hauk 2014; Judson 2015). Ecofeminism and just sustainabilities are intersectional frames informing next wave higher education sustainability education (Agyeman 2013; Mies and Shiva 2014). Materials for teaching sustainability and climate education have become more available, including for teacher preparation candidates and faculty (Bigelow and Swinehart 2014; Sterling 2001; Stibbe 2009). Thus, the research in the field of sustainability education in higher education conveys a complexity of both the intersections of topics and disciplines as well as the types of skills and approaches requisite for this multiplex field (Jones et al. 2010). As Wals et al. (2004) anticipated at the start of the Decade for Education for Sustainable Development,

> Meeting the challenge of sustainability in higher education is culturally embedded…There is no panacea for the failure of institutions to take on this challenge. Some institutions will choose to add on to existing programmes, others will opt for a more transformative approach… Sustainability can be a catalyst for institutional change and for a transition towards higher learning and new ways of knowing (p. 348).

The sustainability education scholarship that has arisen near and after the close of the UN Decade for Sustainable Development has emphasized that more work is needed, that curricular innovations from whole-school to program-specific innovations and local adaptations are still in the margins and have yet to avoid green washing or to affect large-scale, societal, and environmental/ecological/equity change (Huckle and Wals 2015; Jickling and Wals 2012). This survey of the informing literatures from ESD, EfS, and SE establishes that more strategies are needed to bring sustainability education to life in university contexts to optimize the critical and transformative potential of the field and in the world. As we will see in the next literature review, ecopsychology offers emergent qualities and characteristics that could help fill this need.

2.2 Ecopsychology

Emerging from environmental psychology, ecopsychology studies the interconnection between the human and natural world through intertwining ecological and psychological processes. The term was coined in the 1990s to indicate a newly appearing type of psychology which merged ecology and the human psyche (Roszak 1994). Ecopsychology has blossomed into a unique approach to the question of human mental health and the health of overlapping and interrelated global systems. Informed by deep ecology, traditional knowledge systems, Gaia theory, and depth psychologies, ecopsychology has grown up out of a realization that many of the favored tactics and interventions within sustainability fields are incapable of producing the sorts of broad reaching and regenerative impacts they seek to catalyze (Roszak 2009). Ecopsychology is considered by many to be a homecoming, a call to action to address the growing disconnection and alienation of industrial and post-industrial societies (Chalquist 2009) and embrace the reality of global ecological interconnection in response to the same multiplex problems that education for sustainability seeks to address.

Ecopsychology builds a holistic understanding of wellness, drawing from a wide variety of epistemological frames (Corral-Verdugo et al. 2013). Proponents of the field may take ethological, physical, biochemical, and genetic elements into account at one scale of inquiry, while considering thinking, dreaming, spirituality, depth psychology at another scale, and broader systems thinking, complexity, and interbeing at another scale (Fisher 2002). Ecopsychology offers models for how to support people's emotional needs as they raise their awareness of sustainability issues (Edwards and Buzzell 2009). It centers the importance of hopeful perspectives and proposes methods for building different types of perceptual attention that is better able to recognize and attend to ecological problems (Macy and Brown 2014; Macy and Johnstone 2012; Sewell 1995; Thomashow 1998).

Peters and Wals (2013) believed that the "management and control thinking" that is pervasive in traditional approaches to teaching and learning in higher education acts as a block to transdisciplinary integration of environmental and sustainability scholarship (pp. 85–88). They examined how this control orientation is fundamentally inadequate for addressing "complexity, uncertainty and contestation, and multiple causation interactions and feedback loops" (p. 85) in environmental and sustainability concerns. Noting how higher education reproduces and reinforces reductionist approaches to complex problems, they advocated for a transdisciplinary move toward "chaos and complexity thinking" which would revise the role of higher education in creating thinkers capable of catalyzing a sustainable future (pp. 85–88). Ecopsychology is of particular interest to educators in the field of sustainability education who want to divest "management and control thinking" and cultivate nimble, creative, organic and complex problem solving—the kind of post-reductionist orientation that is necessary to improve the reach and impact of education for sustainability.

Because ecopsychology looks specifically at the inherent connections between human mental health and the health and wellness of the natural world, it would be supportive for any programs that expect students to engage deeply with the multifaceted and interrelated problems of the Anthropocene. Roszak (1994) identified that ecopsychology generated the emotional resilience to avoid burnout, frustration and fatigue in environmentalists and activists in their ongoing fight against the destruction of the earth. Students of sustainability face similar enduring concerns and frustrations, and could benefit from the emotional fortification ecopsychology can provide. Ecopsychology further offers models for social emergence in eco-communities of deep dwelling and compassionate mutual action (Chalquist 2007, p. 52; Chalquist 2010). These social models are also life-giving for sustainability education in its emergent aim to extend beyond capacity-building and resilience such "that in order to break with maladaptive resilience of unsustainable systems it is essential to strengthen transgressive learning and disruptive capacity-building" (Lotz-Sisitka et al. 2015, p. 73).

3 Methods

This research performed an analysis of theses and dissertations published since the advent of the UN Decade of Education for Sustainable Development regarding higher education research on ecopsychology and sustainable development using the

Proquest Database. It performed bibliometric inquiry (Ziegler 2009) into the content of the text corpus to determine the categories of inquiry within the body of scholarship of this intersection.

This research queried the full text of theses and dissertations published after January 1, 2004 using the ProQuest database. The date range was January 1, 2004 through the end of March 2016. The ProQuest database is the largest single repository of available, published graduate thesis and dissertation works in the world (ProQuest, n.d.). Our final data set was generated using the following search string: (ecopsychology) AND (sustainable development OR sustainability education) AND (higher education). N = 500.

Researchers then examined the 500 papers using latent Dirichlet allocation (LDA), a type of Bayesian network approach using a probabilistic algorithm which analyzes text corpus to generate an index of associated topics (Blei et al. 2003). Latent Dirichlet allocation looks for words that are frequently associated over multiple text strings and groups them together, performing multi-layer probabilistic mixing to determine how the terms relate across multiple document entries to create probability-linked associations (Blei et al. 2003, pp. 993–995). The researchers examined the resultant terms in each topic cluster (see Appendix B) after removing common terms (Appendix A) and then heuristically selected a term from the field that seemed to best represent the topic cluster terms for the title [Note: Appendix A and B are available online at http://earthregenerative.org/research/data/lda-spring-2016/LDA-appendices-ecopsychology-sustainability-education-2016.html].

Researchers generated the results using a Java engine designed by David Andrew Copeland for the latent Dirichlet. We did run multiple sampling iterations for the model to estimate the parameters of the model, and found similar results. Table 1 lists the twenty topics with five keywords selected as exemplars of the category.

Table 1 Topics and keywords identified using latent Dirichlet allocations

Topic	Name	Keywords
0	Creativity	Art, language, media, creative, awareness
1	Ecological identity	Ecological, I, we, world, narrative
2	Environmental psychology	Environmental, psychology, pro-environmental, attitudes, behavior
3	Indigenous knowledge Systems	Indigenous, cultural, knowledge, land, communities
4	Sustainability education	Sustainability, leadership, education, action, organizational
5	Human-nature relationship	Nature, human, well-being, connection, relationship
6	Environmental justice	Political, critical, justice, environmentalism, movements
7	Climate change	Climate, sciences, public, action, policy
8	Feminist spirituality	Women, spiritual, sacred, body, transformation
9	Sustainable design	Design, conservation, system, consumption, feedback

(continued)

Table 1 (continued)

Topic	Name	Keywords
10	Adventure therapy	Wilderness, therapy, adolescent, program, treatment
11	Social justice	Society, peace, conflict, legal, complex
12	Environmental education	Education, environmental, teaching, curriculum, pedagogy
13	Traditional ecological knowledge	Plants, landscape, traditional, medicine, reclamation
14	Ecopsychology	Ecopsychology, archetypal, self, psyche, unconscious
15	Qualitative inquiry	Experience, research, participants, interviews, phenomenological
16	Place	Place, urban, local, communities, natural, stewardship
17	Research	Research, study, sciences, social, understanding, relationship
18	Ontological questions	Philosophy, theology, ethics, consciousness, cosmological
19	Ideas for change	Transformation, systems, wisdom, participatory, regenerative

Note This table lists the researcher derived names based on latent Dirichlet allocation of title, abstract, keywords and topics of 500 dissertations and theses published on ProQuest since the start of the UN Decade for Sustainable Development, between January 2004 to March 2016 using the search string: "(ecopsychology) AND (sustainable development OR sustainability education) AND (higher education)." Keywords represent five exemplar words chosen from a list of 20 to provide a sense of the category

4 Findings

Findings in this analysis included volume of higher education thesis and dissertation work, counts by topic within this emergent space of research convergence, and focused findings by primary topic with confirmation of significance.

Finding 1 Volume of research in ecopsychology and sustainability education increasing during the UN Decade of Education for Sustainable Development.

This analysis of theses and dissertations published since the advent of the UN Decade of Education for Sustainable Development revealed an increase in volume of higher education research regarding ecopsychology and education for sustainable development within the Proquest Database. While causality cannot be inferred, there is an increase in theses and dissertations in this overlap which coincides with the UN Decade of Education for Sustainable Development (UN DESD). From 1993 to 2004, only 167 dissertations and theses addressed this possible synergy; however, since 2004, 500 papers have been published that represent this trend. Figures 1 and 2 demonstrate the number of published thesis and dissertation research works in these fields over time.

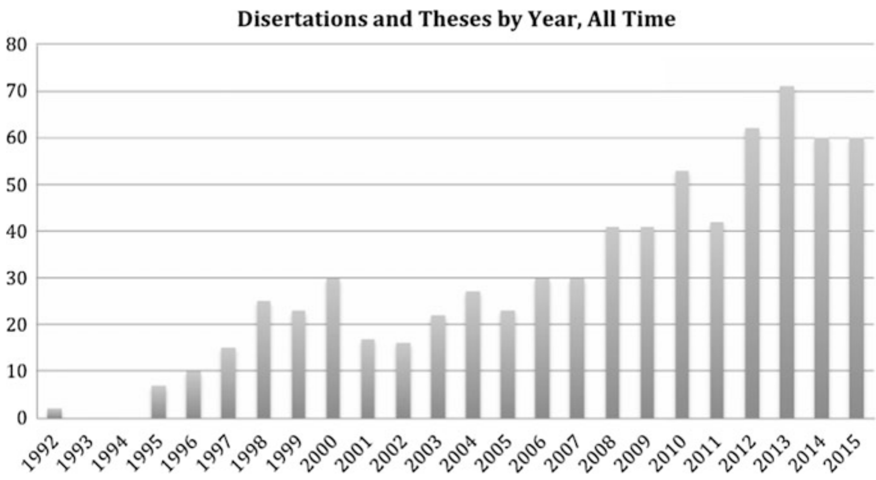


Fig. 1 Number of theses and dissertations for the search string (ecopsychology) AND (sustainable development OR sustainability education) AND (higher education) in the Proquest Database, from 1992 to 2015

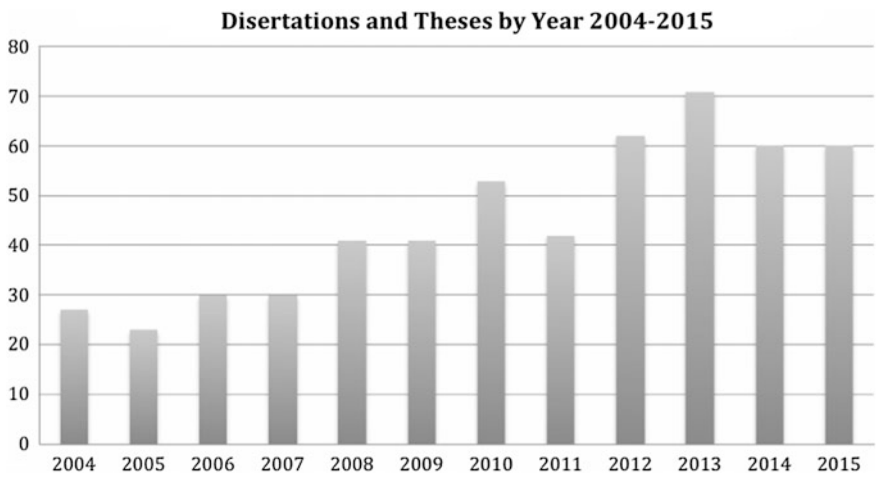


Fig. 2 Number of theses and dissertations for the search string (ecopsychology) AND (sustainable development OR sustainability education) AND (higher education) in the Proquest Database, since the advent of UN Decade for Education for Sustainable Development, January 2004 through March 2015. *Note* Figs. 1 and 2 show the general growth over time in the fusion of the topics of ecopsychology with sustainability education and education for sustainable development in higher education. Figure 1 shows all time results, while Fig. 2 looks more closely at the UN DESD period

Finding 2 Topic trends in emergent topics within these ecopscyhology and ESD/EfS/SE research theses.

Twenty topics were assigned to our sample of theses and dissertations using LDA. 102,305 total topic assignments emerged and were applied to the 500 papers. The most topic assignments made to a single paper was 573. The fewest topics assigned to a paper was 68. Topic 17, *research*, was assigned to 99.4 % of papers and accounts for 24 % of total assignments. This predictable outlier will be excluded from further analysis (Fig. 3).

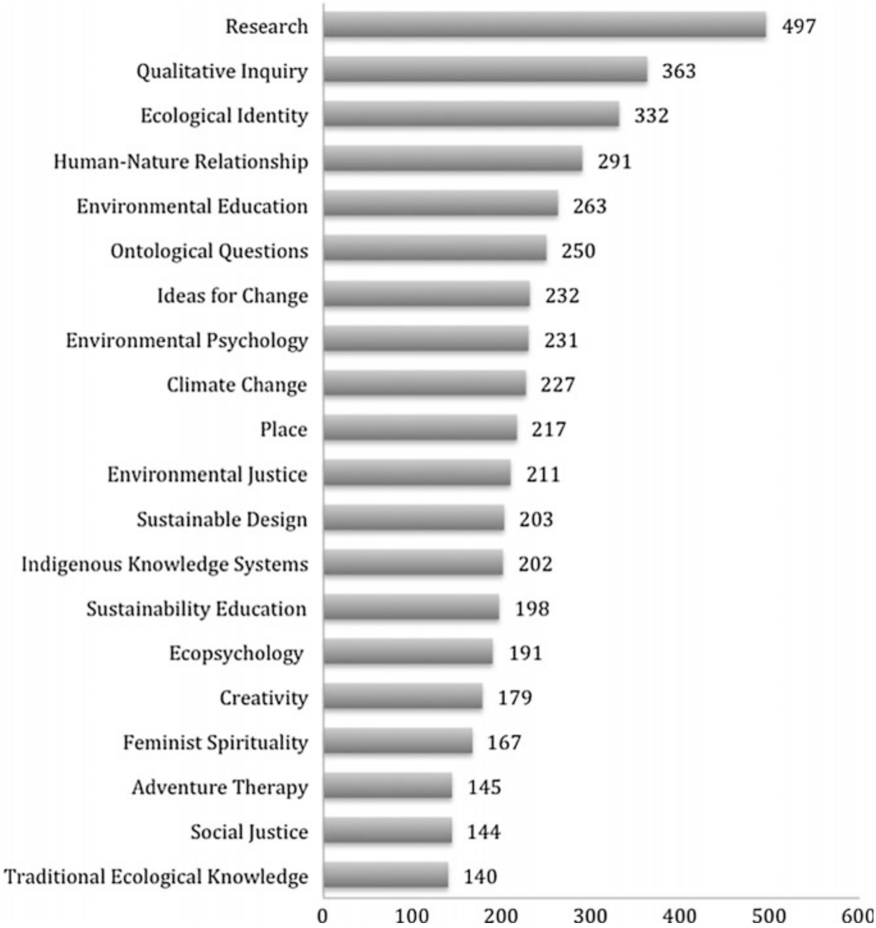


Fig. 3 The twenty topics emergent from the Bayesian network analysis using latent Dirichlet allocation, and the count of total number of research works assigned to each, from the set of January 2004 through March 2016 ProQuest theses and dissertations containing the words ecopsychology, AND sustainability education or education for sustainability or education for sustainable development, AND higher education. *Note* This chart shows the total number of papers to which each topic was assigned at least once (ordered top down, 19–0)

Additional analysis to establish and verify frequency and primary topical alignment were also conducted and will be reported in subsequent research publications. They are not included here due to space constraints.

5 Discussion

This research identified 20 topic trends that exist in the intersection of education for sustainable development and ecopsychology in higher education research. These topics represent the ways in which extant and ongoing research scholarship at the graduate level has adopted a transdisciplinary approach to these fields, and the ways the growing synergy of disciplines is currently informing and supporting the growth of sustainability scholarship in education through student research.

A continuing need, and gap. Our literature review revealed a continuing gulf in the effective adoption and realization of the promise of education for sustainability. The complex, multiplex, transdisciplinary challenges of sustainability require connective and integrative capacities. Primary topical categorization of higher education master's and doctoral work published since the advent of the UN Decade for Education for Sustainable Development revealed a significant and increasing interest in ecopsychology in higher education within sustainability discourses and research. This missing competency might well provide the messy entanglement and critical and creative embodiment that Selby and Kagawa have signaled requires additional attention in sustainability education (2015, p. 278).

In addition to this invitation to inter- and transdisciplinary work at the boundary blurring edges, Wals (in Jickling and Wals 2012) emphasized the "post normal" moment in sustainability education at the end of the DESD, "the 'post-Rio' challenge for educators and researchers with a planetary consciousness. In the years to come, this challenge will require a re-imagining of education and the development of new forms of learning that require the fields of EE and ESD to enter unknown terrain" (2012, p. 54).

Supporting metacognitive flexibility and boundary blurring. Lotz-Sisitka et al. (2015) noted an increase in the literature indicating "the need for more radical social learning-centered transformation in relation to sustainability concerns" (p. 73). They argued that the "indeterminate and boundary crossing nature of sustainability issues… creates new challenges for higher education" (p. 73) and that these new challenges call for a reconceptualization of the approaches to learning and pedagogy. Lotz-Sisitka et al. propose a transcendence of the imposed, dualistic disciplinary boundaries to achieve the complexity of structural support necessary for addressing wicked problems in uncertain times. This amounts to an epistemological shift in the approach to sustainability education in the university setting. Ecopsychology supports the frame awareness and this epistemological move from an individualist pedagogy informed by dualistic assumptions toward an ecological understanding of complex and interconnected being (Leetch 2015; O'Conner 1995; Peters and Wals 2013).

Inner resilience for resilient, sustainability systems. Our findings provide support for what sustainability education theorist Sterling (2010) has advocated for as a twinned strategy of increased internal resilience and increased knowledge of catalyzing resilient systems, what he has called "a transformative education paradigm—'sustainable education'—which necessarily integrates instrumental and intrinsic views and which nurtures *resilient learners* able to develop *resilient social-ecological systems* in the face of a future of threat, uncertainty and surprise" (2010, p. 511).

Adding ecopsychology in the sustainability university curriculum. Ecopsychology is particularly important when considering the student scholar as a whole being. Engaging with the multiplex issues of building a sustainable society can be overwhelming, disheartening, and can lead to fatigue, burnout, and an inability to retain individuals in the field (Macy and Johnstone 2012; Roszak 2009). By helping students to develop complex and multi-perspective thinking around their role in addressing and mitigating these issues, new sustainability students are fortified in the resilience offered by interbeing, a sense of time that is broader than recent history known as *deep time*, and a complex systems orientation to how change occurs in self-organizing and emergent systems (Macy and Johnstone 2012). This opening of perspective can also serve to produce scholars who transcend the limiting paradigms of reductionist specialization, cultivating a sophisticated and multi-pronged systemic understanding more fitting to the complexity of the present epoch (Krasny and Dillon 2013; Lotz-Sisitka et al. 2015). Ecopsychologically informed pedagogies and content can help with sustainability education's deep aims, to "strive toward deep learning and reorientation by conscious design…[as] transformative learning depends on the nature of the learning experience we have ourselves and…to provide for others" (Sterling 2004, p. 68).

We suggest ways in this discussion and conclusion that ecopsychology can support next generation sustainability education, as indicated by the trend analysis in scholarly research in the field.

6 Conclusion

This research analyzed the text corpus of dissertations and theses at the intersection of sustainability education and ecopsychology to identify emergent trends and areas of scholarship since the advent of the UN Decade of Education for Sustainable Development. It identified 20 topics within the research convergence which represent the leading edge of combined inquiry in ESD and ecopsychology, which we consider representative of the concept of earth care. This fusion is supported by the convergence of transdisciplinary social learning with ecological skills of perception.

6.1 Recommendation: Ecopsychology in the Curriculum and the Classroom

Based on the growing realization of the power of generalist knowledge and the importance of inter- and transdisciplinary learning, it is our recommendation that ecopsychology be brought into the sustainability education classroom, pedagogy, and curriculum. Ecopsychology helps to cultivate the necessary epistemological orientation toward interbeing that supports and sustains the ongoing development of solutions to multiplex sustainability issues. Ecopsychology provides a common language to aid discourse across disciplines and build the capacity to identify value-based coalition actions within the university.

One way this could be handled is by creating an introductory class that attends to and strengthens students' ecopsychological resilience while initiating them into the psychological and sociocultural aspects of sustainability problems. This course could help to create a common lexicon across departments that increases the interest in education for sustainability. Another important element of ecopsychological influence to integrate ESD more fully into institutions of higher learning would be the development of creative, imaginal and transdisciplinary approaches across disciplines and curricular elements to deepen the potential of sustainability thinkers to be resilient, nimble, and adaptive in the face of mounting vulnerability (Hauk 2014; Selby and Kagawa 2015; Sterling 2010). Several research studies have affirmed the robust benefits of deepening sustainability education curriculum, including enhancements in student retention, competency acquisition, participation levels, empathy, compassion, solidarity, transdisciplinarity, distanced reflection, and motivation (Barth et al. 2007, p. 418). In particular, ecopsychology as an explicit presence in higher education sustainability programs supports "higher stages of consciousness and cognitive complexity" while also supporting interiorization (pp. 418–419), nurturing "local, creative, and participatory solutions to problematic conditions and institutions by transforming their psychological relationship to self and other, sometimes in dialogue with [those] who are transgressing academic boundaries…to regenerate hope and a sense of agency through the birthing of novel… spaces for creative dialogue" (Watkins and Shulman 2008, p. 16). Koger and Scott (2007) affirmed the bidirectional nature of the benefit in the necessary integration of sustainability and psychology curricula (p. 11). In this interdisciplinary path of integrated approach, psychology students could also become sustainability advocates and thus agents of individual and structural change.

Ecopsychology is well-positioned to serve as a strengthening study for interior stamina and resilience and integrative and curricular bridge to communication and action for sustainability education. Sterling (2011) included ecopsychology in curriculum as an example of curricular interventions to achieve higher order thinking, meta-learning and epistemic learning, in transformative sustainability education (p. 28). Psychology-sustainability department collaborations have proven effective in higher education at engaging in successful interdisciplinary neighborhood regeneration projects, for example (Bradley et al. 2010, p. 266). Thus in context, content, approach, pedagogy, competency-building, student stamina, embedment, metacognition, complex transdisciplinarian capabilities, and structurally integrative thinking, the literature supports our recommendations regarding the explicit inclusion of ecopsychology coursework in sustainability education higher education curriculum, as well as the potential twining of sustainability and ecopsychology approaches across the curriculum and in the nonformal contexts of living and learning surrounding such curricular content.

6.2 Limitations and Future Directions

This research was limited in the scope of its analysis. It is limited by the challenges of transferability of particular sustainability higher education approaches (Adomssent et al. 2007). Further research would consider the convergence of topics within the text corpus samples to find papers which strengthen and support the inclusion of an ecopsychological orientation within ESD. Further work could also identify the ways in which the text in the corpus directly represents this fusion, and can be applied to higher educational paradigms that seek to further integrate education for sustainable development into their programs. A future direction for this research would be to perform a curricular analysis of top sustainability education degree-granting programs to see how our LDA generated topics compare to the curricular threads within said institutions.

Acknowledgments Authors would like to thank Data Scientist David Andrew Copeland for his assistance with the probablistic modeling and the use of his custom Java engine for latent Dirichlet allocation. No external funding. Lists of words removed during pre-processing and lists of LDA topic assignment terms are available via email from the researchers or online at http://earthregenerative.org/research/data/lda-spring-2016/LDA-appendices-ecopsychology-sustainability-education-2016.html.

References

Adomsentt, M., Goddemann, J., & Michelsen, G. (2007). Transferability of approaches to sustainable development at universities as a challenge. *International Journal of Sustainability in Higher Education, 8*(4), 385–402.

Agyeman, J. (2013). *Introducing just sustainabilities: Policy, planning and practice*. London: Zed Books. 205p.

Barth, M., Godeman, J., Rieckmann, M., & Stoltenberg, U. (2007). Developing key competencies for sustainable development in higher education. *International Journal of Sustainability in Higher Education, 8*(4), 416–430.

Bigelow, B., & Swinehart, T. (2014). *A people's curriculum for the Earth: Teaching climate change and the environmental crisis*. Milwaukee, WI: Rethinking Schools. 410p.

Blei, D., Ng, A., & Jordan, M. (2003). Latent Dirichlet allocation. *Journal of Machine Learning Research, 3*, 993–1022.

Bradley, J. F., Sayce, S., & Lewis, A. (2010). Sustainability and built environment professionals: A shifting paradigm. In S. Sterling, P. Jones, & D. Selby (Eds.), *Sustainability education: Perspectives and practice across higher education* (pp. 257–272). London: Routledge.

Buzzell, L., & Chalquist, C. (2009). Psyche and nature in a circle of healing. In Authors (Eds.), *Ecotherapy: Healing with nature in mind* (pp. 17–21). San Francisco: Sierra Club Books.
Chalquist, C. (2007). *Terrapsychology: Reengaging the soul of place*. New Orleans, LA: Spring Journal Books. 158p.
Chalquist, C. (2009). Ecotherapy research and a psychology of homecoming. In L. Buzzell & Author (Eds.), *Ecotherapy* (pp. 69–81). San Francisco: Sierra Club.
Chalquist, C. (Ed.). (2010). *Rebearths: Conversations with a world ensouled*. Walnut Creek, CA: World Soul Books. 392p.
Corral-Verdugo, V., Garcia-Cadena, C. H., & Frias-Armenta, M. (2013). *Psychological approaches to sustainability: Current trends in theory, research and applications*. New York: Nova Science. 473p.
Corcoran, P. B., & Wals, A. E. J. (2004). *Higher education and the challenge of sustainability*. Norwell, MA: Kluwer. 355p.
Doherty, T. J. (2011). Ecopsychology and environmentally-focused psychologies: APA 2011 Conference report on environmentally-focused psychology. *Environmental, Population, and Conservation Psychology Bulletin*, Oct.
Edwards, S., & Buzzell, L. (2009). The waking-up syndrome. In L. Buzzell & C. Chalquist (Eds.), *Ecotherapy: Healing with nature in mind* (pp. 126–275). San Francisco: Sierra Club.
Fisher, A. (2002). *Radical ecopsychology: Psychology in the service of life*. Albany: State University of New York Press. 306p.
Hauk, M. (2014). Gaia e/mergent: Earth regenerative education for empathy, creativity, and wisdom (Doctoral dissertation). Proquest (UMI 3630295). Last accessed January 3, 2016 http://pqdtopen.proquest.com/doc/1563382491.html?FMT=ABS
Huckle, J., & Wals, A. E. J. (2015). The UN decade of education for sustainable development: Business as usual in the end. *Environmental Education Research, 21*(3), 491–505. doi:10.1080/13504622.2015.1011084
Jickling, B., & Wals, A. E. J. (2012). Debating education for sustainable development 20 years after Rio: A Conversation between Bob Jickling and Arjen Wals. *Journal of Education for Sustainable Development, 6*(1), 49–57. doi:10.1177/097340821100600111
Jones, P., Selby, D., & Sterling, S. (2010). More than the sum of their parts? Interdisciplinarity and sustainability. In S. Sterling, P. Jones, & D. Selby (Eds.), *Sustainability education: Perspectives and practice across higher education* (pp. 17–37). London: Routledge.
Judson, G. (2015). Re-Imagining sustainability education: Emotional and imaginative engagement in learning. In D. Selby & F. Kagawa (Eds.), *Sustainability frontiers: Critical and transformative voices from the borderlands of sustainability* (pp. 205–220). Opladen, Germany: Barbara Budrich Publishers.
Kahn, R., & Humes, B. (2009). Marching out from Ultima Thule: Critical counterstories of emancipatory educators working at the intersection of human rights, animal rights, and planetary sustainability. *Canadian Journal of Environmental Education, 14*, 173–195.
Koger, S. M., & Scott, B. A. (2007). Psychology and environmental sustainability: A call for integration. *Teaching of Psychology, 34*(1), 10–18. Retrieved from http://www.willamette.edu/cla/psychology/pdf/koger_article2.pdf
Krasny, M. E., & Dillon, Justin. (2013). *Trading zones in environmental education: Creating transdisciplinary dialogue*. New York: Peter Lang.
Leetch, A. (2015). Schemas, groups, and mindset in ecopsychology (Unpublished manuscript). Arizona: Prescott College.
Lotz-Sisitka, H., Wals, A. E. J., Kronlid, D., & McGarry, D. (2015). Transformative, transgressive social learning: Rethinking higher education pedagogy in times of systemic global dysfunction. *Current Opinion in Environmental Sustainability, 16*, 73–80.
Macy, J., & Brown, M. Y. (2014). *Coming back to life: The updated guide to the work that reconnects*. Gabriola Island, BC: New Society Publishers. 343p.
Macy, J., & Johnstone, C. (2012). *Active hope: How to face the mess we're in without going crazy*. Novato, CA: New World Library. 272p.

Mies, M., & Shiva, V. (2014). *Ecofeminism*. New York: Zed. 360p.
O'Conner, T. (1995). Therapy for a dying planet. In T. Roszak, M. Gomes, & A. Kanner (Eds.), *Ecopsychology* (pp. 149–155). San Francisco: Sierra Club Books.
Peters, S., & Wals, A. (2013). Learning and knowing in pursuit of sustainability: Concepts and tools for transdisciplinary environmental research. In M. E. Krasny & J. Dillon (Eds.), *Trading zones in environmental education: Creating transdisciplinary dialogue* (pp. 79–104). New York, NY: Peter Lang.
ProQuest. (n.d.). ProQuest dissertations and theses global (Web page). Retrieved from http://www.proquest.com/products-services/pqdtglobal.html
Roszak, T. (1994). Ecopsychology and the anima mundi. *Revision, 16*(3), 108.
Roszak, T. (1995). Where Psyche meets Gaia. In Author, M. E. Gomes, & A. D. Kanner (Eds.), *Ecopsychology* (pp. 1–20). San Francisco: Sierra Club.
Roszak, T. (2009). A psyche as big as the earth. In L. Buzzell & C. Chalquist (Eds.), *Ecotherapy: Healing with nature in mind* (pp. 30–36). San Francisco: Sierra Club.
Sewell, L. (1995). The skill of ecological perception. In T. Roszak, M. Gomes, & A. Kanner (Eds.), *Ecopsychology*. San Francisco: Sierra Club.
Selby, D., & Kagawa, F. (Eds.). (2015). *Sustainability frontiers: Critical and transformative voices from the borderlands of sustainability*. Opladen, Germany: Barbara Budrich, 295p.
Shoreman-Ouimet, E., & Kopnina, H. (2015). Reconciling ecological and social justice to promote biodiversity conservation. *Biological Conservation, 184*, 320–326.
Sipos, Y., Battisti, B., & Grimm, K. (2008). Achieving transformative sustainability learning: Engaging head, hands, and heart. *International Journal of Sustainability in Higher Education, 9*(1), 68–86.
Sterling, S. (2001). *Sustainable education: Re-visioning learning and change*. Devon: Green Books. 94p.
Sterling, S. (2004). Higher education, sustainability, and the role of systemic learning. In P. B. Corcoran & A. E. J. Wals (Eds.), *Higher education and the challenge of sustainability* (pp. 49–70). Norwell, MA: Kluwer.
Sterling, S. (2010). Learning for resilience, or the resilient learner? Towards a necessary reconciliation in a paradigm of sustainable education. *Environmental Education Research, 16* (5–6), 511–528.
Sterling, S. (2011). Transformative learning and sustainability: Sketching the conceptual ground. *Learning and Teaching in Higher Education, 5*(2010–11), 17–33.
Stibbe, A. (2009). *The handbook of sustainability literacy*. Devon: Green Books. 220p.
Thomashow, M. (1998). The ecopsychology of global environmental change. *The Humanistic Psychologist, 26*(1–3), 275–300. doi:10.1080/08873267.1998.9976976
Wals, A. E. J. (Ed.). (2007). *Social learning towards a sustainable world.* Wageningen, 537p.
Wals, A. E. J., & Blewitt, J. (2010). Third-wave sustainability in higher education: Some International trends and developments. In S. Sterling, P. Jones, & D. Selby (Eds.), *Sustainability education: Perspectives and practice across higher education* (pp. 55–74). New York: Routledge.
Wals, A. E. J., Walker, K., & Corcoran, P. B. (2004). The practice of sustainability in higher education: A synthesis. In P. B. Corcoran & A. E. J. Wals (Eds.), *Higher education and the challenge of sustainability* (pp. 347–348). Norwell, MA: Kluwer.
Watkins, M., & Shulman, H. (2008). *Towards psychologies of liberation*. New York: Palgrave Macmillan. 380p.
Ziegler, B. (2009). Methods for bibliometric analysis of research: Renewable energy case study. Working Paper CISL# 2009–10. Boston: Massachusetts Institute of Technology. Last accessed January 3, 2016 http://web.mit.edu/smadnick/www/wp/2009-10.pdf

Author Biographies

Amanda Leetch is a graduate research student at Prescott College studying critical ecopedagogy and ecopsychology. She received her undergraduate degree from Lesley University in developmental psychology with a focus on attachment and end of life processes. She spent ten years working as an early childhood educator, scaffolding children and families to support the growth of securely attached, resilient children. Through the study of systems theory and ecopsychology, she has come to recognize the need for widespread systemic changes that address sustainability issues through the lens of complex interconnection. Her current research focuses on how ecological perception can be cultivated to create opportunities for complex, localized meaning-making within student populations.

Marna Hauk, Ph.D. serves as a postdoctoral scholar at Prescott College in Sustainability Education, where she mentors and teaches graduate students. She instructs graduate courses in Regenerative Design, Climate Change Education, Sustainability Education, Facilitating Biomimicry, Environmental Justice, Ecopsychology, Ecofeminism, and Leadership and the Imagination. She also serves as Faculty of Regenerative Sustainabilities and directs the graduate education programs for the Institute for Earth Regenerative Studies (www.earthregenerative.org) in Portland, Oregon. Dr. Hauk is a 2014–2016 Community Climate Change Fellow of the North American Association of Environmental Education and the EPA. She actively researches, with over seventy peer-reviewed publications and presentations, including publishing with *Ecopsychology*, the *Journal of Environmental Education*, the *Australian Journal of Environmental Education*, the *American Educational Research Association*, the *Association for the Advancement of Sustainability in Higher Education*, and the *Journal of Sustainability Education.* Dr. Hauk's areas of research include education for climate change and justice, sustainability education, complex systems, regenerative biomimicry, ecopsychology, historical trauma and intergenerational place connection, bioculturally responsive curriculum, ecopreneurship and ecosocial incubators, higher educational design, and advanced research methods.

Creating a Sustainable Campus from the Ground up

Peter Walker and Sandra Mendler

Abstract

The newly developed Chatham University Eden Hall Campus, home to the Falk School of Sustainability and Environment is the first new university campus in the world to be built sustainably from the ground up, featuring full cycle water recycling, net positive energy production, and zero waste operations in an immersive living and learning environment that will ultimately house 1200 residential students. The first phase of construction—the first dormitory, a field lab and hoop house, café and dining commons with classrooms facilities designed to support 250 students—is complete and has been occupied since 2015. The campus is intentionally a work in progress, a place and object of inquiry, as the buildings, landscapes and infrastructure have been developed as an active research environment including building technology, renewable energy systems, sustainable agriculture and food systems, aquaculture, water treatment and nutrient recovery, watershed protection, soils, wildlife and habitat, etc. The campus cultivates a sense of wonder about the natural world, and invites mindful living as it engages daily awareness of how individuals and communities impact resources and living systems. This paper outlines the six-year long process of visioning and building the campus, and its initial occupancy. The challenges of building a new campus and working to realize high expectations are addressed, as well as the evolving student interest and awareness of this fundamentally different campus environment. Ultimately the completed campus provides a partial answer to the central research question of whether educational outcomes

P. Walker (✉)
Falk School of Sustainability and Environment, Chatham University,
Eden Hall, 6035 Ridge Rd, Gibsonia, PA 15044, USA
e-mail: Pwalker@chatham.edu

S. Mendler
Mithun, 660 Market Street, Suite 300, San Francisco, CA 94104, USA
e-mail: sandym@mithun.com

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_19

will be stronger and campus partnerships will be enhanced by this immersive living-learning environment that invites on-going sustainability research. The campus vision is bold, yet implementation takes time and perseverance, providing rich learning opportunities for students along the way.

Keywords
Sustainable campus · Integrated design · Net positive · Sustainability research · Satellite campus · Living-Learning environment

1 Introduction

This paper sets out to describe, reflect upon and draw lessons from the six-year process of conceiving, building and bringing to life a brand new sustainable university campus, which has become the home of the new Falk School of Sustainability and Environment at Chatham University. We believe this is the first such campus in the USA, built from scratch and as such provides many lessons for other such ventures.

Chatham University is building a new School of Sustainability and Environment on the Eden Hall Farm in Richland Township, 25 miles north of Chatham University's Shadyside Campus and downtown Pittsburgh. The new campus, home to a new school, is also the first new university campus in the world to be built sustainably from the ground up, featuring full cycle water recycling, net positive energy production, and zero waste operations. It has been envisioned as a "living lab for healthy sustainable living" that will engage students and attract participation locally, nationally and internationally. The campus integrates high performance buildings and infrastructure into a sustainable working landscape, demonstrating sustainable use of the land rather than a conservation approach that would attempt to conserve original pre-development site conditions.

The campus is demonstrating success in meeting sustainability goals through recognized third party assessment including "LEED" Platinum for all buildings, Living Building Challenge for its bunkhouse, Passive House for the future residence lodge, and Sustainable Sites Initiative guidelines for the site. The campus will provide a unique living and learning environment where students and visitors can experience the sense of wonder that is evoked by the natural world together with a strong sense of community and culture.

Detailed designs have been completed for the following: Dining Commons, Dairy Barn café, Field Laboratory with science lab classroom and aquaculture demonstration, EcoCenter with gallery space, classrooms and a large multi-purpose lecture hall, two Dormitories and a Residence Hall designed for hosting conferences and events. Site infrastructure includes an amphitheatre, a demonstration landscape called the "mosaic field"; a state-of-the-art hoop house and aquaculture facility for year round production, constructed wetlands for onsite wastewater to provide biological treatment of sewage waste with water and nutrient recovery. Linked energy systems include photovoltaic panels (PV), solar hot water and geothermal cogeneration. With construction underway, and the first phase scheduled to complete in spring 2016, these facilities will define the core of the new Eden Hall Campus.

2 Methodology

In seeking to document why and how this campus evolved, the authors have drawn upon the detailed planning and construction records held by the university, interviews with the university's senior management team who have directed the project from the outset, and their own personal involvement. Sandy Mendler, principal with Mithun, was the integrated design leader for the project, working closely with the campus and the full design team. Chatham University hired Mithun as their architect to bring the campus vision into reality—providing architecture, landscape architect and interior design, and leading a consultant team of specialists in an integrated design process. The Mithun team held extensive on-site workshops at Eden Hall, bringing their design team to Chatham and working closely with a passionate design committee including faculty, staff, board members and student representatives. Peter Walker became Dean of the Falk School of Sustainability the Environment in the summer of 2014 and moved the School's faculty and students to the campus in the fall of 2015. This paper also draws upon the extensive planning sessions and town hall meetings held in the School as the move to Eden Hall was planned and implemented and upon graduate projects initiated by the students as they explored the social, governance and economic aspects of the new campus. Since both Mendler and Walker have been intimately involved in the Eden Hall project and are vested in its success, the authors have tried to guard against observer bias by drawing from the written record and from the views of others involved in the development of the campus. Nonetheless, we are well aware that our view is essentially an optimistic one, seeing the campus as a still ongoing living, learning experiment.

3 What Is a Sustainable Campus?

With the seminal publication of the Brundtland report, Our Common Future, in 1987 a working definition of sustainability was adopted that has stood the test of time, namely, sustainability means our ability to meet the needs of the present generation without compromising the ability of future generations to meet their own needs.[1]

Since then, the academic and planning community has sought to unpack this definition, adding detail, identifying specific ways of measuring and tracking progress towards sustainability and applying the concept to specific environments, such as the university campus.

Robin Ried, in a 2008 white paper for the US Green Building Council on using LEED as a resource in sustainable campus planning, points out that “the concept of sustainability can be applied to education, research, and learning as well as the physical imprint of the campus itself on the natural environment”.[2]

The Association for the Advancement of Sustainability in Higher Education (AASHE Stars system, used by many universities to map and measure their degree of sustainability, covers five categories of indices, relating to: academics, engagement, operations, planning and administration, and innovation and leadership.[3]

Mitch Thomashow in his recent book, the Nine Elements of a Sustainable Campus, outlines what he thinks goes into a sustainable campus, from his experience as president of Unity College. He identifies three aspects of the campus, with three subsets of issues in each.

Infrastructure

- energy, food, and materials

Community

- governance, investment, and wellness

Learning

- curriculum, interpretation, and aesthetics

Chatham, like many universities, uses the AASHE star system to track its overall sustainability, however, in the process of building out the new Eden Hall campus we are as interested in exploring how sustainability can be exemplified and improved as we are in measuring sustainability as it has conventionally been defined.

---

[1]World Commission on Environment and Development (1987) Our Common Future: Report of the World Commission on Environment and Development. Transmitted to the General Assembly as an Annex to document A/42/427, Development and International Cooperation: Environment. Online at http://www.un-documents.net/wced-ocf.htm, accessed 7-2-16.

[2]Ried R (2008) Using LEED as a Resource for Campus Sustainability Planning: A White Paper. US Green Building Council. Online at http://www.centerforgreenschools.org/sites/default/files/resource-files/UsingLEEDforCampusSustainability.pdf, accessed 7-2-16.

[3]AASHE (2016) Stars Technical Manual, Version 2.1. Online at http://www.aashe.org/files/documents/STARS/stars_2.1_technical_manual.pdf, accessed 7-2-16.

For us, inheriting a 388 acre site of woods and farm land, once the country estate of a founding member of the Heinz food empire, and on it creating a brand new campus with a brand new school, we are having to imagine, plan and implement across the spectrum of sustainability, from the high capital and precisely measured creation of new energy systems, to the low cost and desperately difficult to measure building of community and creation of health enhancing aesthetics. Thus the process of getting there and what we learn from it is just as important as reaching predefined goals of sustainability.

To help us in this, we are working with a variant on Thomashow's nine elements of a sustainable campus:[4]

Infrastructure

- energy, water, land and buildings

Learning

- curriculum, interpretation, and aesthetics

External Community

- society, economy and governance

Internal Community

- governance, wellness and happiness

We have ordered them here more or less in the sequence we have had to tackle them, and will use this framework later in the paper to describe what we have achieved, learned and are still worrying about (Fig. 1).

4 Historical Context

Pittsburgh has been a leader in the green building movement, with the leadership of the Pittsburgh Green Building Alliance, and the solid support now of the city mayor's office. It's history of shifting from "the city that built America"; coal, steel and accompanying atrocious air and water pollution, to a down-sized, cleaned up city with an "eds and meds" economy has been well documented.[5] Having rebuilt itself in the post WWII period and again after the collapse of the coal and steel

[4]Thomashow M (2014) The Nine Elements of a Sustainable Campus. MIT Press, Cambridge.

[5]Tarr Joel A, ed (2004) Devastation and renewal: an environmental history of Pittsburgh and its region. University of Pittsburgh Press, Pittsburgh.

Fig. 1 View of existing barns from the main stage of the Amphitheatre; an outdoor gathering space designed as part of the phase 1 campus development; the Dairy Barn on the right has been renovated into a campus cafe

industries in the 1980's, Pittsburgh and its hinterland is once more looking to rebuild, with a focus on sustainability and resilience; from green buildings to urban renewal and concern for local food systems, the city is looking to the future.[6]

Pittsburgh sits in Allegheny County, and Eden Hall is at the northernmost extremity of the country, and at the highest point in the county's watersheds. The matrix landscape of suburban Allegheny county includes a few remaining patches of open land interspersed with residential subdivisions and commercial development. The 388 acre Eden Hall site provided an important opportunity to demonstrate sustainable land use practices in the faster growing portion of Greater Pittsburgh—Allegheny County's population of 1.23 million is nearly four times the population of the downtown area, which numbers just 305,000.[7] Protecting water quality of streams is an especially important challenge in Allegheny County—Pennsylvania has more impaired waterways than any other state and Allegheny

[6]Resilient Pittsburgh website (2016) Pittsburgh's participation in the 100 Resilient Cities initiative. Online at http://www.pittsburghpa.gov/innovation-performance/resilience/, accessed 2-8-16.

[7]US Census (2014)Population estimates. Online at http://www.census.gov/quickfacts, accessed 2-7-16.

County is the most challenged part of the state, with environmental degradation from overflow of untreated sewage.[8]

Finally, the Eden Hall Farm legacy of service to women, as a place to restore and revitalize in nature, aligns with Chatham University, historically a women's college. The history of Eden Hall is succinctly described in the master plan for the campus.

"Since the early 19th Century, Eden Hall Farm has served as a place for focused connection with nature. As a farm, a resort, a preserve, and now a laboratory, the genius of the land continues to inspire generations of bodies and minds to explore, discover, learn, and renew. Upon his death in 1938, Sebastian Mueller, Senior Vice President of the H.J. Heinz Company and charitable humanitarian left his farm to be used as a resort where women in the region could revitalize through nature. Serving this purpose until 2008, the land remained largely untouched amidst booming neighboring development and is now one of the largest undeveloped tracts of land in Allegheny County, Pennsylvania. In 2008, Eden Hall Foundation donated the 388-acre farm to Chatham University to further the university's educational objectives and, in doing so, created an extraordinary opportunity for immersive research and advancement in the arena of environmental study."[9]

5 Conceiving the Campus

The original vision for the campus and School, presented to the university's board of trustees in 2009 as the land was gifted to the university, sees a bright future.[10] The vision for a sustainable campus was conceived by President Esther Barazzone and her staff after a summer road trip to visit campuses and sites that exemplified sustainability through architecture, design and education. Subsequently, a master planning team (BNIM and Andropogon) was hired, and long discussions with Bob Berkebile and his team, authors of the 2011 campus master plan developed a comprehensive vision for the campus.

Serving the needs of current and future generations, Chatham University at Eden Hall will serve as a beacon to those who wish to imagine and model sustainable learning and living. Through scholarly training and research, Eden Hall Campus will create entrepreneurs and advocates capable of implementing sustainable ideas and sharing them with a global community. In so doing, Chatham will proudly advance the legacy of Rachel Carson, class of 1929.[11]

---

[8]Hopey D (2012) Region's rivers are some of nation's most polluted: Ohio River heavy with toxic discharge. Pittsburgh Post-Gazette. Online at http://www.post-gazette.com/news/nation/2012/03/23/Region-s-rivers-are-some-of-nation-s-most-polluted/stories/201203230179, accessed 1-8-16.

[9]BNIM and Adropogon (2011) A Splendid Vision: Chatham University, Eden Hall Master Plan, p 4. Online at http://falk.chatham.edu/documents/ehc-masterplan.pdf, accessed 8-2-16.

[10]Chatham University (2009) Vision for the future of Chatham University's Eden Hall campus. Private correspondence presented to the Chatham University Board of Trustees.

[11]BNIM and Adropogon (2011) A Splendid Vision: Chatham University, Eden Hall Master Plan. p 6. Online at http://falk.chatham.edu/documents/ehc-masterplan.pdf, accessed 8-2-16.

The mission of the Falk School of Sustainability and Environment was seen as preparing new leaders who would help sustain the long-term health of the biosphere and the well-being of its people; research and problem solving would be integral to the school's mission. While the mission and teaching of the Falk School will be infused throughout Chatham's campuses, the innovative buildings and site infrastructure at Eden Hall will provide rich opportunities for hands on learning in an immersive living and learning environment.

The new campus was master planned for 1200 residential students when fully built out in 20–25 years. In addition to student uses, a district at the northern edge of campus called Elsalma will ultimately be a commercial farm for organic farming and aquaculture, run primarily but not exclusively with student workers living on campus to study organic farming and sustainable agriculture practices. Much of the forested portion of the campus will be preserved as a long term platform for research and education. The university has committed to an open-source approach to research and data generated on the campus and woodland.

New buildings on campus would showcase the latest developments in green building technology. All buildings constructed at EHC would be a physical manifestation of the School's and Chatham's commitment to providing human environments that help sustain the larger community as well as the natural environment. In early 2011, Chatham hired Mithun as their architect to bring the campus vision into reality—providing architecture, landscape architect and interior design, and leading a consultant team of specialists in an integrated design process. The Mithun team held extensive on-site workshops at Eden Hall, bringing their design team to Chatham and working closely with a passionate design committee including faculty, staff, board members and student representatives.

Tellingly, the university looked beyond land management and architecture. "But this is about far more than finding an architect, designer or planner who is familiar with the latest green building technology. This is about finding architects, designers and planners who are willing to work with Chatham to build a green and sustainable community at EHC (Fig. 2)."[12]

6 What We Had to Work with

As the university that was Rachel Carson's Alma Mater, Chatham had a strong commitment to and history of environmental concern. It is regularly listed amongst the top green and sustainable universities by the Princeton review, the Sierra Club, the International Sustainable Campus Network and Second Nature.[13] This practice is backed up by a strong commitment from the university's board of trustees and

[12]Chatham University (2009) Vision for the future of Chatham University's Eden Hall campus. Private correspondence presented to the Chatham University Board of Trustees.

[13]Chatham University website (2016) http://www.chatham.edu/about/documents/SustainabilityAwards_0815.pdf, accessed 2-8-16.

Fig. 2 Aerial view of core campus—phase 1 development

senior administration, to promoting sustainability and promoting Chatham as an educational leader in this field. This is important. Sustainability at Chatham is not confined to one school, or an academic program, but represents a substantial commitment across the university. Chatham is a small Master's level university with some 2200 students and annual revenue in 2015 of $56 million. To date it has invested over $50 million in the land, buildings and systems of Eden Hall, a substantial commitment for a small university. Funding has come from generous gifts and grants from Pittsburgh foundations, government entities and private individuals ($26 million), the university's endowment (6 million) and a commercial loan ($18 million).

The township that the campus sits in has also been supportive, welcoming the commitment to keeping the campus as an aesthetically pleasing area and one that adds value to the township, given Chatham's commitment to put 40 % of the land in permanent conservation easement and to provide substantial landscape buffers along the perimeter of the campus. Town hall meetings were held with local residents to better understand their hopes and concerns. And throughout the site's initial development since 2008, frequent and regular meetings have been held with the township, county and state bodies whose regulatory oversight is essential to the development of the site.

The site itself sits at the highest point in the county, feeding two watersheds that eventually drain into the Ohio. It is about two thirds wooded and one third farmland, with a scattering of farm buildings as well as the old country house of Sebastian Muller and a two story guest house built in the 1960s. Most of the land is sloping and the soils are heavily worked, high in clay and thinning. Rainfall tends to come as short heavy downpours, combining with the steep impervious slopes to aggravate runoff and on occasions flash flooding. The woodland is all secondary regenerative growth, most of it naturally seeded but with a few stands of closely planted pine. As is common in the state, white tailed deer inhabit the land in abundance, eating anything that isn't fenced off. Groundhogs and wild Turkey are also common, as well as a Coyote pack and possibly a Black Bear in residence.

Access to the campus from Pittsburgh is via Route 8, a congested undivided arterial route with over twenty sets of lights between the Eden Hall campus and the main Chatham Shadyside campus, and no connecting public transportation. University shuttles busses run between Pittsburgh and the Eden Hall campus however the vision for the campus is as a residential place where students spend extended periods of time, with video-conference technology providing links to institutions and students beyond.

Demographically, the area around the campus is one of the fastest growing regions of greater Pittsburgh, and many new housing developments surround the campus, however the nearest town offering shopping and restaurants is some 9 miles to the west. The Eden Hall campus provides an alternate model for developing a large parcel of open space in the matrix of suburban sprawl that is so common in the United States. The model is of the "New Farm" which is designed to export energy, clean water and food locally, while providing the co-benefits of habitat preservation, watershed protection as well as educational and cultural amenity.

7 Integrated Design of Buildings and Systems

As the first university campus planned for sustainability from the ground up, Eden Hall Campus is designed to inspire students with a hands-on living and learning environment. The Mithun team designed the buildings, the landscape and the integrated systems to enable "closed loop" food production, energy generation and water treatment systems. The multi-functional "mosaic" landscape includes rain gardens, a natural treatment wetland, agriculture and orchards interwoven with forests and meadows (Fig. 3).

7.1 Campus Energy Systems

The "net energy positive" Eden Hall campus is grid connected, so that excess energy generated can be shared, with a predicted net gain of 10 % as the first phase of development is completed. Buildings were designed to meet highly efficient energy targets; averaging 20 EUI for building loads exclusive of food prep and aquaculture systems. Sources of renewable energy include photovoltaic (PV) on rooftops and as free standing canopies, solar hot water and geothermal wells. A small (10 kW) co-generation plant in the dining commons produces electricity and hot water using natural gas with bio-fuel equivalency, part of a long term waste to energy strategy. An energy loop links buildings in the core campus, enhancing

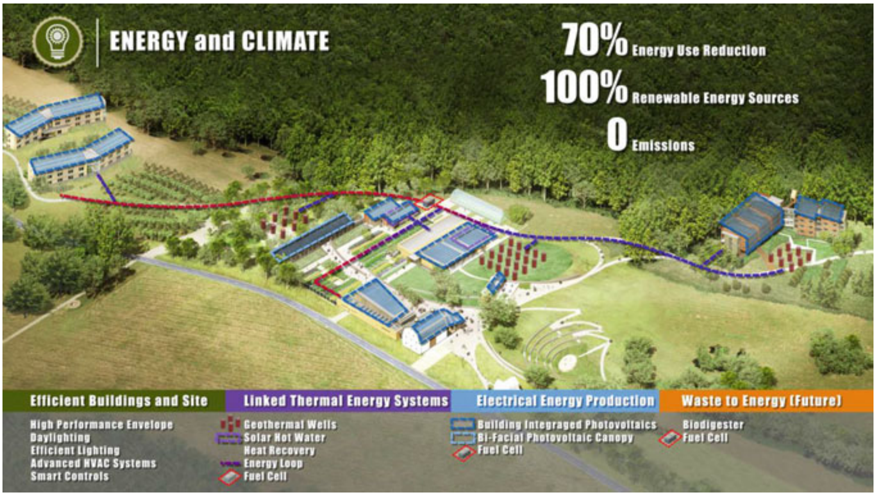


Fig. 3 Diagram of campus energy systems illustrating campus energy loop, geothermal wells and renewable energy systems (note that fuel cell has been replaced with combined heat and power cogeneration system in the final design, with future plan for biofuel production from on-site composting)

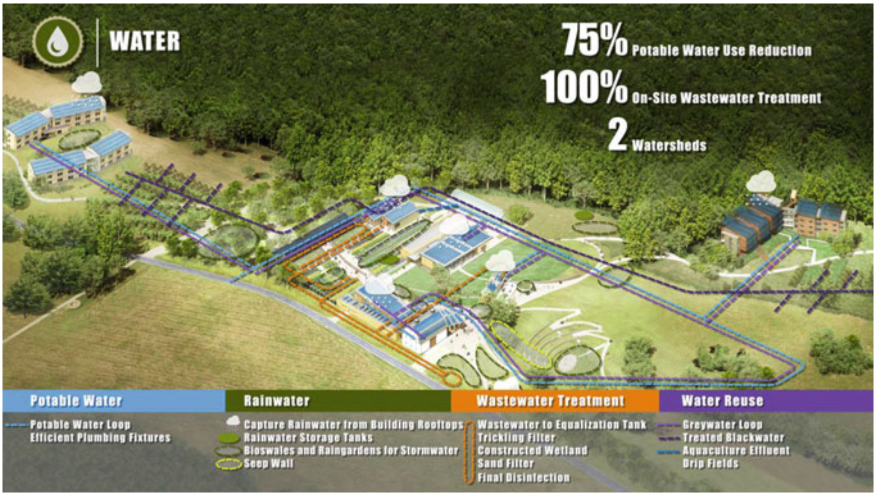


Fig. 4 Diagram of campus water systems illustrating rainwater infiltration areas, rainwater collection and reuse, and onsite biological treatment of waste water for non-potable reuse

the efficiency of individual buildings as low temperature condenser water acts as a thermal sink to increase the efficiency of cooling equipment and distributes excess heat to other buildings. Real time energy monitoring is provided to track energy use and energy generation throughout the campus (Fig. 4).

7.2 Campus Water Systems

Water is managed as a valuable resource on campus with rainwater collection and on-site biological wastewater treatment for reuse as well as groundwater recharge. The wastewater system treats greywater and blackwater and reuses treated effluent for toilet flushing, irrigation and groundwater recharge, using a low energy plant-based system with an initial design flow of 6000 gallons per day. Rainwater from rooftops is captured and held in below ground cisterns for reuse, so no potable water is used for irrigation. Twenty-four rain gardens are seamlessly integrated into the topography where water naturally collects, to capture, slow and infiltrate 100 % of the rainwater from built hard surfaces including roofs, sidewalks, streets, and parking lots with six below grade infiltration galleries. These gardens employ deep-rooted native shrubs, perennials, and grasses to collect and hold water in soils prepared to slowly infiltrate water into the ground, completing the cycle within 48 h so that mosquito larvae do not have time to hatch. Water quality of receiving streams is improved as stormwater is filtered and slowed down to reduce erosion during storms.

7.3 Buildings

All of the buildings on campus will be LEED Platinum at a minimum, and all are designed with passive solar design principles, reducing the need for energy use through daylighting, sun control, high performance well-insulated building envelopes and natural ventilation. Advanced energy efficient lighting and lighting controls are used throughout, and the rooftops of all buildings include solar PV and rainwater collection, with some also including solar hot water. The first four completed buildings include a Field Lab, Dairy Barn Café, Dining Commons and the Orchard Dorms, and are described briefly below:

7.3.1 Dining Commons

The Dining Commons is a state of the art farm-to-table kitchen and dining facility, with a 250-seat dining room serving as dual purpose conference space, classrooms and demonstration cooking areas with integrated AV systems on the main level. A double height skylit "vertical farm" extends into the basement level which houses a media classroom for distance learning, a sustainability monitoring room providing real time energy and water data for campus buildings and infrastructure, and a dirt floor root cellar providing natural temperature and humidity control. Integrated kitchen and building energy systems include radiant slabs, heat recovery from ventilation and refrigeration, and electric induction cooking. Full composting and on-site water treatment systems provide water and nutrient recycling (Fig. 5).

Fig. 5 The field lab is pictured on the left, the commons building on the right and the Hoop House is visible in the distance

7.3.2 Orchard Residence

The Orchard Residence has been designed to promote health and wellness for students and visitors, as well as the environment. All rooms have operable windows, excellent daylight and views, individual climate controls on a room by room basis, and 100 % fresh air with no re-circulating air between rooms. Wellness is also supported with informal gathering spaces on each floor, a gym on the upper level, and conveniently located daylight stairways to encourage walking. Super-insulation and deep overhangs on south facing windows boost building efficiency together with an innovative radiant heating and cooling system embedded in the gypsum board ceiling, quietly heating and cooling without any separate radiator or fan. Heat recovery systems and solar hot water panels integrated with rooftop PV provide heat for domestic hot water (Fig. 6).

7.3.3 Dairy Barn Cafe

The Dairy Barn Café serves locally produced organic food in a compact zero-waste facility with limited packaging and all waste recycled or composted. The renovated building retains the spirit of the original with all interior wood framing preserved and shadows of cows etched onto the floor as a palimpsest. A new high performance shell with insulation and locally manufactured concrete rain screen cladding meets high efficiency goals, and energy recovery ventilators combined with natural ventilation provide a healthy, efficient and comfortable environment.

Fig. 6 The Orchard Dorm provides student housing on campus for an immersive living and learning environment

7.3.4 Field Lab

The Field Lab at the edge of the Mosaic Field offers diverse research opportunities with an aquaculture lab for yellow perch and other coldwater species, a Treated Sanitary Effluent (TSE) Room for final filtration and polishing of the core campus wastewater, and a lab classroom where students can monitor water quality and biological systems. Four types of water—city potable water, rainwater, TSE, and aquaculture effluent—are used for water quality and agricultural research. A glass-fronted mechanical room displays energy recovery ventilator equipment and geothermal systems, and glass walls into the TSE Room and beyond make the water treatment system visible as a whole (Fig. 7).

8 The Farm and Woodland: Its Evolution and Purpose

As the Chatham design committee and the Mithun team worked to develop the design, the idea of seeing the entire campus—not just the agricultural portions—as the “New Farm” came into being. Careful choices had to be made about the siting of buildings and infrastructure to protect quality soils for agricultural use, while accommodating buildings, infrastructure and farming of various types, including growing fields, orchards, enclosed hoop houses and aquaculture. The topography provided an additional challenge as much of the land was on slopes, placing flat

Fig. 7 The Hoop House provides space for year round growing with water supplied from collected rainwater and treated effluent

land at a premium as it is preferred for farming and is also the most economical and logistically best placed for the construction of the new campus buildings. Both interim and comprehensive land use planning was needed to address these challenges.

A soil survey was carried out which allowed us to identify the areas with the best and deepest soils. One 25 acre field was chosen as the focus for farm development. A long time organic farmer from the region was hired to direct and manage the farm. We decided to focus on building up the soil quality of that field and doing so in a way that would eventually lead to us getting organic certification for the land. In addition, 5 acres of the field were fenced off with deer fence, to allow for vegetables to be grown. A half acre kitchen garden already existed next to the old country home of Sebastian Mueller. This was fenced and revived along with the original adjacent 1920s green house. Finally two unheated hoop-houses were put up as temporary installations to create a longer growing season and to ensure that cultivation and harvesting of some crops could be delayed such that students arriving in the fall could be involved in harvesting.

In 2015 a year-round hoop house heated by solar thermal panels was installed adjacent to the field lab and dining commons, allowing us to grow salad crops through the winter and to have space for seed trails, experiments with hydroponics and other student projects.

The initial goals of the farm were twofold, to improve the land and to produce vegetable and other crops for consumption in the university canteens. A few students interned on the farm from the beginning but in the initial years the farm was not really integrated into the curriculum.

Farmland not put down to cultivation was left as open meadow. Some was rented out for cattle grazing and the rest mowed annually to keep the weeds under control until the land was either built on or brought into production.

The woodland we inherited had been unmanaged for many years. At one time there was at least ten miles of bridleways through it, but by 2008 this had dwindled to less than 2 miles. From 2008 until 2015 the existing trails were maintained and the only other work associated with the woods has been to discourage illegal deer hunting.

9 The Falk School: Its Evolution and Initial Residency at Eden Hall

The Falk School of Sustainability, which was created in parallel with the Eden Hall campus, has itself evolved as the potential of the campus and its challenges became more evident. The first intake of graduate students was in 2010 for the already established Food Studies program, and 2012 for the new Sustainability program. Undergraduates arrived in 2014. Taking as our starting point a notion of sustainability as an approach that leads to "an economy, serving society, within Earth's life support system limits" and a commitment to being a school deeply involved in making this vision happen, we chose to style ourselves as a professional school, concerned with training students to get meaningful jobs that position them to change society. Thus we have not chosen to build a PhD program yet and have concentrated on undergraduate and Master's level programs and leveraging them to allow as many students as possible to be exposed to the sustainability agenda.

Our starting undergraduate degree covers the full range of sustainability fields, environmental, social and political, business and economics, and cultural. We have no required subject areas for students coming in and so work with a wonderful mix of student types and knowledge base, deliberately making a virtue out of this diversity by involving students within the classroom in mentoring their peers. Within the degree program, students can focus on one of four areas, in a nine credit concentration.

The Sustainability major is also offered as a minor across the university and will soon be offered as part of an interdisciplinary degree track, which allows students to take half their studies in one major and half in another. Double majors are also being encouraged with complementary programs such as Communications, Psychology, Social Work and Business Studies. We also offer an integrated degree track where students can take 12 graduate credits in their final undergraduate year, allowing them to carry on and get their master's degree in the School with only one additional year of study, albeit an intensive one. Thus they enter the workforce a year earlier than normal and having paid one year less fees.

Our rationale is to package the undergraduate offerings in as many ways as possible to allow for many more entry points to the study of sustainability and thus marketing the program to a greater range of students.

At the graduate level we offer two two-year masters, one in Sustainability and one in Food Studies. All the degrees emphasize experiential and project based learning. All students do internships and all do a final dissertation or thesis.

The School moved from its location on the old Chatham campus to Eden Hall in the summer of 2015 ahead of the first phase of the campus building program being completed in the spring of 2016.

10 What Have We Learned

In the early summer of 2016 the construction teams finally left the campus and the students and faculty finished their first year of working and teaching on the campus: a good time to reflect on what we have learned, the mistakes we have made and where we go from here. We have structured our conclusions around three themes, the evolving nature of the campus vision and construction, the reality check of this first year in residence, and our hopes for the future.

10.1 The Evolved Concept for the Campus

The Eden Hall campus been envisioned as a unique destination that will inspire students while also engaging a diverse set of visitors and partners, locally, nationally and internationally. Early visits to Stone Barns, a farm in New York State demonstrating sustainable agriculture technologies and conducting ongoing research in an authentically beautiful farm setting, served as a model and inspiration for the campus, as Stone Barns attracted visitors and became a dynamic gathering place for thought leaders and innovators, stimulating technology transfer.

We are clear that Eden Hall cannot work as a commuter campus for the main campus. Yet while the campus is being built out, and until there is a sufficient critical mass of students on campus, there will be daily commuting, especially for undergraduates as the full range of General Education courses they need is not yet offered at Eden Hall.

As with so much in sustainability our challenge is one of transition. We know that the campus needs to be when fully built out and up to speed with a vibrant residential community, but how do we get from where we are now, a just-finished construction site with commuter students, to the final vision?

10.2 First Year's Residency: What Have We Learned?

The School moved its offices to the campus in August 2015 and from then on sought to teach the majority of its courses on campus. For this first year, we have had 25 students in residence on campus. Most of these are not Sustainable School students, but students from other schools attracted by the low residence costs at Eden Hall, as we heavily discount accommodation costs for this first year. So, what have we learned in this first year?

10.2.1 Infrastructure

The campus geothermal system and photovoltaic systems are up and running, heating buildings and providing electricity. They work effectively, but until we have finished building the dining commons at the center of campus, the energy monitoring systems will not be accessible to faculty and students. For sustainability students this is a disappointment. In "selling" the campus we talked up the interactive nature of the systems and the ability to work with real data, but the vagaries of construction got in the way. Issues with the geology affecting foundation building, an unseasonably long winter delaying concrete pouring, and sub-contracted supplier issues all conspired to put completion six months behind schedule.

The downside is that we have not been able to deliver fully on the promise, but the upside is that students have a much more realistic appreciation of just how difficult it is to implement new technology in an old technology setting. The real lesson from this is that the marketing of any new campus or program needs to be firmly tied to the reality of what is going to be delivered. This means that marketing messages need to be adjusted as the construction program unfolds and developed.

10.2.2 Learning

Some of the campus systems are readily available for teaching. The farmland and greenhouses are up and working as is one of the kitchens. The woodland with streams and marshes is accessible and the local urban community is accessible. Courses in food studies, agroecology, greenhouse production, ecology and water systems have been able to make hands on use of the campus facilities, pushing the vision of project based and experiential learning. The student garden on the farm has allowed us to test different forms of composting and we have installed a full composting system for the campus kitchens. The aquaculture lab is not yet fully running but students have gone ahead and built their own smaller aquaculture system, using recycled material from the campus and are stocking it with fish for the first live run, as we write. Given the opportunity, faculty and students are creative and keen to utilize an experiential based learning approach.

10.2.3 External Community

Through internships and projects our students have solidly engaged with the local community. We have worked with community groups in the more deprived areas of

Pittsburgh to map local green spaces and ecological resources. Student has engaged in designing and helping start urban farming projects, community bread ovens and new farmers markets. Our sustainable business studies courses have teamed up with local startup groups to field test soil moisture sensors, peat moss substitutes made from recycled paper and a local direct delivery salad company, started by our students, that now needs a reliable and organic source of micro-salad-greens. Building these projects into the curriculum has significantly increased students job skills and ability to get jobs after graduating. In a city like Pittsburgh though, with many competing universities, we do have a concern over the sustainability of this approach. Can we ensure sufficient community projects for a growing and continuing body of students?

10.2.4 Internal Community

Progress on the internal community has been slower as we are essentially still dealing with a commuter community of students, commuting from our original campus, some 25 miles and one hour drive away. The university shuttle bus service currently provides one trip every two hours, and we have endeavored to group classes in sequence so students can come out for the day.

For the small number of residential students, the campus Student Life Director has created workshops and social events geared to this sustainable campus: Wilderness survival, mushroom production, visits to local farms.

Students in our Sustainability/MBA dual masters carried out a survey in fall 2015 looking at how students across the university perceived the new Eden Hall campus and the transport facilities to get them there. To highlight some of the results from their on-line survey:

- about 75 % of surveyed students perceive the shuttle bus between the two campuses as inconvenient
- 90+ % know that EHC is a sustainable campus
- about 80 % learned about the EHC prior to starting classes at Shadyside
- 20 % of survey participants have no idea how long it takes to travel between campuses
- even though over 90 % of participants know that EHC is a state of the art sustainable campus, about 65 % indicated that sustainability in general does not relate to their field of study.

Clearly, we have what amounts to a chicken and egg challenge. Until we have sufficient students living at Eden Hall, the perceived cost of commuting, for many students, outweighs the benefits of using the campus, but the full benefits of the "living learning" campus will not be apparent until we have a critical mass of residential students.

11 Where Do We Go from Here?

As we approach our second residential year at Eden Hall, there are some key lessons we can take away from our experience so far.

First, building the cutting edge infrastructure of a sustainable campus in a local regulatory environment not used to such things, requires a constant process of communication, negotiation and education, whether it has been with the local township or the state. Building projects, particularly innovative ones, never go according to plan, and each hiccup and potential deviation from the originally agreed master plan requires explanation and negotiation.

Second, everything takes longer than planned. Building completion dates slip and slip again, that's just reality and the academic agenda just has to go with this, and crucially, the marketing strategy for the campus and programs also has to evolve. We have to sell the reality, not just the dream.

Third, all the effort of building out the physical plant, buildings and landscape, are of no value if you can't build a vibrant intellectual and social community on top of it, and this stage requires just as much dedication to communication, education and negotiation as the building phase did. As with the buildings, deadlines slip and expectations have to be revised. In some ways, building a sustainable community in a university has particular challenges. True, universities are some of the most sustainable, and longest lasting, institutions in the country, far outliving most companies, and in other countries, far outliving even the couriers themselves. But, universities embody clear divisions between administration, faculty and students. They are administratively hierarchical and ironically conservative in their management style. If we are trying to model sustainable governance and society then collaborative and shared systems should be prominent. This is not just a matter of more transparency (though that is necessary), it means finding ways to share decision making, as well as responsibility for successes, and failures. Building this new take on campus live, the sustainable community is, we think, the biggest challenge ahead of us.

Finally, there is a particular set of challenges associated with transiting from an empty campus to one with sufficient residents to give the critical mass needed for a vibrant community. The transition is a hurdle you have to jump over, and an initiation you have to go through, if you are to build a truly sustainable campus. The trick is understanding that it is transition, not an end state. It is all too easy to get caught up in the urgency of schedules, student life, budgets and accreditation, but your eyes have to stay firmly on the important, the vision of a fully sustainable campus, in all its manifestations.

12 Conclusion

The vision that motivated the Chatham University administration and its trustees to embark on a new Eden Hall Campus was bold—to create a new campus model that supports hands on experiential learning in an environment that actively engages students with their environment—the buildings as well as the landscape and natural systems. It is an experiment in higher education based on the hope and expectation that students will be empowered and enriched by their experience at Eden Hall campus, and partnerships will be enhanced as the campus engages the sustainable development community broadly. The early results of this experimental campus are positive but not conclusive as the campus community is still forming. The challenges the campus faces now involve growing enrollment, completion of additional facilities to build critical mass of activity on campus, and development of robust sustainable governance that will be as innovative as the built systems.

Acknowledgments It took cooperation between many organizations and many people to conceive, construct and start using our new sustainable campus. The university board of trustees, administration, faculty and students had to work together to envision what the new campus would be like. The designers, architects, planners and builders all had to be actively involved. We are particularly indebted to:
Mithun: Architecture, Landscape Architecture, Interior Design, and Design Integration
Interface Engineering: Mechanical, Electrical and Plumbing Systems
Biohabitats: Constructed Wetlands and Water System Design
Civil and Environmental Consultants (CEC): Civil Engineer
KPFF: Structural Engineer
CJL Engineering: Commissioning Agent
Rothschild Doyno: On-site project management
Sota Construction: General Contractor
Without the involvement and cooperation of the local Richland township and the people of the township, we could not have suggested such a radically different campus and finally, without the involvement of the present students, faculty and staff up at Eden Hall, we could not now be testing, implementing and improving the model.
All photos and diagrams were created and provided with permission from Mithun.

Sustainability Champions: Role Models in Sustainability Graduate Education

Michael C. Cavallaro, Martin Boucher and Toddi A. Steelman

"Models are one of the most important pedagogical agents in the history of education"

Anton A. Bucher (1997, pp. 620).

Abstract

Sustainability champions are iconic men and women who have shaped the scholarly understanding of sustainability by considering broad, alternative, and visionary solutions to sustainability problems. For instance, sustainability champions such as Rachel Carson, Aldo Leopold, Wangari Maathai, Daniel Quinn, and Vandana Shiva have disciplinary expertise whose inspiration has radiated through the pillars of sustainability, crossing disciplines in natural and social sciences. The roles played by sustainability champions and their role in sustainability education have not been fully explored. This study aimed to identify sustainability champions within an academic unit focused on sustainability research, to provide context for their inspiration, and bring attention to the use of role models in sustainability graduate education. Using survey results from students, faculty, post-doctoral fellows, and staff within the School of Environment and Sustainability at the University of Saskatchewan, we discovered that the sustainability champions they selected embodied diverse backgrounds and expertise: writers, artists, professors, activists, and politicians. Participants were mostly inspired by individuals in the Professor category, representing 33.8 % of the 47 total survey responses. However, other categories such as Writer/Artist received moderate attention with 18.3 % and both Activists and Multiple (more than one category) with 15.5 %. Furthermore, surveyed faculty credited their sustainability champion for broadening their views and

M.C. Cavallaro (✉) · M. Boucher · T.A. Steelman
School of Environment and Sustainability, University of Saskatchewan,
Saskatoon, SK S7N5C8, Canada
e-mail: michael.cavallaro@usask.ca

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_20

research, whereas students felt their champions opened them to new ideas. More than half of students, faculty, post-doctoral fellows, and staff surveyed indicated their sustainability champions had changed at some point during their academic career—possibly demonstrating that impression from a sustainability champion can inspire at any stage of career.

Keywords
Education · Curriculum · Interdisciplinary · Role model · Academic supervisor

1 Introduction

Effective construction, implementation, and dissemination of sustainability graduate education curricula continue to pose challenges for sustainability practitioners and educators around the globe (Leal 2011). Impacts of climate change, biodiversity loss, chemical pollution, water availability, and energy production are exerting tremendous pressure on the provisioning of natural resources and other planetary life support systems (Rockström et al. 2009). Many in higher education are striving to improve educational models by redefining priorities and enhancing social competencies that align with the principles of sustainability and sustainable development (Wiek et al. 2011; Leal et al. 2015). How education can contribute to achieving sustainable development and sustainability continues to be an open area of research (Barth and Michelsen 2013). No matter what educational course of action is selected, a key to this future is well-prepared, adaptive, and dynamic students.

Students engaging in sustainability education often must cross disciplinary borders to tackle new theory, methods, and approaches beyond their traditional academic comfort zone (Cortese 2003). One potentially underused technique for demonstrating how sustainability science can be learned and practiced is through the use of mentors or role models. Through their lived experience, role models can provide an aspirational example to a student to follow as they pursue their own career in sustainability. During early stages of education (grades K-12), role models, or heroes, have been used to integrate learning, guidance, and the development of ideas (Rose 2004; Bricheno and Thornton 2007), but they seemingly have not been explicitly promoted as examples in higher education. While not always fully acknowledged, mentor-based educational models are built into the graduate education process with the appointment of an academic program supervisor, or advisor (Hunter and Devine 2016).

Role model education refers to a transfer of knowledge that goes beyond pure facts, or information, to represent an embodiment of personal attitudes, professional values, and lifestyles (Rose 2004). Sustainability champions are one form of role models that can be instructive to those seeking to identify a path through sustainability education given the current lack of clear trajectory. Sustainability champions as a basis for role model education is not well covered in the peer-reviewed literature. While there is some scholarship dedicated to student supervisor relationships (Hunter and Devine 2016), there is a paucity of work on the role of mentors in sustainability education.

We define sustainability champions as: *iconic men and women who have shaped the scholarly understanding of sustainability by considering broad, alternative, and visionary solutions to sustainability problems*. Most importantly, sustainability champions are people who have influenced others' thinking to transform the way they think about sustainability issues. Using formal role models is not a common curricular practice; however, the formal and informal use of mentoring, peer groups, and shadowing have proven to be valuable tools in graduate education (Ryan et al. 2012; Anderson et al. 2013).

Our goal in this article is to raise awareness about sustainability champions as a strategy to motivate and provide guidance to future sustainability practitioners and professionals. In the section that follows we provide further background on the interface between sustainability and interdisciplinarity to contextualize the need for alternatives given the challenges students face throughout their sustainability graduate career. Thereafter, a methods section elaborates on the context for the study and survey instrument. A combined results and discussion section is offered before concluding with a short section on potential application, awareness, and future implications of role models in sustainability graduate education. By investigating these relationships, we hope to further improve the graduate education experience for students enrolled in sustainability programs.

2 Challenges of Complexity in Sustainability Education

Future generations, including students within and outside sustainability education, are faced with addressing the challenges of sustainable development. Humans represent significant drivers of the biosphere, hydrosphere, geosphere, and atmosphere (Steffen et al. 2007). Recovery and remediation of substantially affected planetary boundaries (c.f. Rockström et al. 2009) will rely heavily on innovations and insights from future sustainability practitioners and their educators. Characteristics of sustainability science include a problem-oriented, or solution-oriented, focus with a pragmatic emphasis; the need to appreciate complex systems and the multiple disciplines that contribute to potential problem understanding and solutions, including the biophysical, social and applied sciences relevant to understanding these complex systems (Roy et al. 2013; Pooley et al. 2014).

While we understand the concepts of multidisciplinarity, interdisciplinarity, and transdisciplinarity in theory, their practice has been more elusive (Roy et al. 2013; Steelman et al. 2015). A multidisciplinary approach involves the use of disciplinary experts working on a research project in a compartmentalized fashion—"multidisciplinary is more additive rather than integrative" (Roy et al. 2013, p. 1). Interdisciplinarity is distinct from multidisciplinarity and transdisciplinarity "in its level of coordination among researchers and across research disciplines"

(Nielsen-Pincus et al. 2007, p.2). Furthermore, the transdisciplinary approach involves the use of stakeholders, often as nonacademic participants, for knowledge development (Pooley et al. 2014; Steelman et al. 2015).

Here, we view sustainability champions as pioneers of interdisciplinarity. To many students the concept of interdisciplinarity might be completely new or intimidating to confront. In our experiences discussing these topics with students enrolled in sustainability graduate education, these concepts are difficult to operationalize within their own research. Strategies directly or indirectly utilized by these champions provide working examples to address these complexities and illustrate how to operationalize sustainable development concepts. If we are to create a robust generation of sustainability practitioners, the literature suggests we need examples of individuals who have worked seamlessly between disciplines and with communities to effect change (Zare and Metzger 1999; Pooley et al. 2014). Sustainability champions may provide an avenue for successfully dealing with the complexities embodied in sustainability problems.

3 Methods and Analysis

3.1 Study Context

The School of Environment and Sustainability (SENS) at the University of Saskatchewan is dedicated to problem-oriented, interdisciplinary, and community based research and teaching. SENS is currently a home academic unit for 22 core faculty, 14 post-doctoral fellows, and 108 students in thesis based and professional degree programs. Curricula are designed to demonstrate interdisciplinarity through team taught courses featuring instructors from different disciplines and to prepare students for careers to meet the sustainability and environmental challenges of the future.

3.2 Survey Methodology

A survey questionnaire consisting of seven questions was used to assess the attitude and opinion of SENS students, faculty, post-doctoral fellows, and staff towards sustainability champions. The topic of the survey included: academic stage of career, age, field of study, discipline(s) of expertise, selection of sustainability champion, and related questions about the participant's selection. Questions were both closed and open ended. Participating students, faculty, post-doctoral fellows, and staff were asked to identify their sustainability champion and comment on the attributes that guided their selection. The survey was conducted online using Fluid Surveys™ and distributed via email directly to all members of SENS.

A total of 153 participants were identified within SENS. The survey was open for a total of 30 days. A total of 47 students, faculty, post-doctoral fellows, and staff completed the survey for a response rate of 30.7 %. Among the six groups of participants, staff (*n* = 6, 67 %) had the highest response rate. Response rates from other groups are as follows: core faculty (*n* = 8, 36 %), professional students (*n* = 6, 30 %), postdoctoral fellows (*n* = 4, 29 %), thesis oriented masters student (*n* = 10, 26 %), and thesis oriented doctoral students (*n* = 12, 24 %). 40.9 % of all respondents considered themselves natural scientists, 40.9 % social scientists, and the remaining 18.2 % selected "other". The majority of the respondents who answered "other" noted that they were a combination of social scientist and natural scientist. Selected responses included: "both social and biological", "interdisciplinary", or "both a social and natural scientist".

When asked, "What discipline(s) do you self-identify?" 13 % of participants responded disciplinary, 76.1 % responded interdisciplinary, 30.4 % responded multidisciplinary, 19.6 % responded transdisciplinary, and the remaining 6.5 % responded "other". Furthermore, participants were asked their disciplinary background. With a total of 130 responses among the 47 participants the responses ranged from: cultural anthropology, public policy, agriculture, to fluvial geomorphology and more. The range of disciplines identified speaks to the diversity amongst the SENS as an academic unit. The results indicated there was a range of disciplinary backgrounds. This is consistent with the overall faculty and student body at SENS. Bias in the respondents' data could not be identified.

3.3 Thematic Analysis

Basic descriptive statistics were used to compare the sustainability champions identified by subgroups and in aggregate. Thematic analysis was used for both the sustainability champions and the open ended question #7: What impact does your sustainability champion have on your sustainability graduate education (student) or graduate teaching (faculty)? Identified sustainability champions originated from a diverse range of occupations, geographic locations, and disciplines. In brief, a total of 71 sustainability champions were identified. Each champion was searched via Wikipedia to understand how they were publicly characterized. We sought to answer the question: "Based on biographical data, what is the primary position of influence of this individual?" Here, we define "position of influence" as the medium, or route, where the sustainability champion was seen as most influential. On this basis, we inductively developed six categories: (1) professor, (2) writer/artist, (3) activists, (4) multiple, (5) family/friends, and other, as indicated in Table 1. Wikipedia was used because it is the only single-point database that contained nearly all of the sustainability champions and provided reliable and quality content (Black 2008). After the methodology for the thematic analysis was developed, additional coding was conducted independently by two of the authors to ensure consistent placement of champions into thematic areas.

An inductive thematic analysis (Braun and Clarke 2006) was used to uncover patterns of how the sustainability champions influenced the respondents' experiences within sustainability graduate education. We used an initial exploratory

Table 1 Summary of thematic codes assigned to sustainability champions

Thematic area	*n*	Definition
Professor	24	Identified by respondent as their professor, or based on biographical search, the person holds/held an academic appointment within higher education
Writer/artist	13	Identified by respondent by their written work or artistic pieces, or based on biographical search, a person who contributed significant written work, artistic piece in other media (e.g., photography, music, sculpture)
Activists	11	Identified by respondent as an activist, or based on biographical search, a person who campaigns for some kind of social or political change
Multiple	11	Multiple thematic areas were identified by a single respondent
Family/friends	9	Identified by a respondent as a family member or friend
Other	3	Position of influence was not identified by respondent. Does not fit into other category definitions

Table 2 Summary table thematic analysis of responses to question #7

Thematic Area	*n*	Definition
Introduced new ideas	11	The sustainability champion introduced new concepts, ideas, and subject matter to the respondent
Broader view	10	The sustainability champion allowed the respondent to understand the interconnections of his/her expertise/research within a broader set of knowledge
Inspiration and motivation	10	The sustainability champion was a source of motivation and inspiration for the respondent's work
Reinforced knowledge	6	The sustainability champion confirmed an existing knowledge base of the respondent and/or provided information for application in the respondent's own work
Critical thinking	2	The sustainability champion allowed the respondent to increase the quality of analysis of information and/or delve into a greater depth of knowledge

methodology to provisionally code and uncover patterns within the responses. This inductive process led to five categories that represented a diversity of perspectives of influence from the sustainability champions: (1) introduced new ideas, (2) broader view, (3) inspiration and motivation, (4) reinforced knowledge, and (5) critical thinking, as indicated in Table 2. After the selection of the five thematic areas, we re-coded each thematic area for consistency. Responses that reflected more than one thematic area were coded multiple times.

3.4 Research Limitations

Several limitations should be considered while interpreting the results of this study. Our response rate was lower than we would have liked. We could not infer the respondents' representation back to the sample populations, so we did not have a sense of how representative our sample was within SENS. For instance, perhaps only those students, faculty, post-doctoral fellows, and staff who were interested in sustainability and interdisciplinarity responded to our survey and therefore our sample is biased in this direction. Furthermore, we sampled only one graduate program and this constrains our ability to have the results speak to a larger constituent of the sustainability education community. Several of our respondents selected sustainability champions popular to western culture, specifically Canada. These circumstances limit our ability to generalize to a larger, global audience.

4 Results and Discussion

4.1 Who Are Sustainability Champions?

Sustainability champions were coded into six categories with the Professor (33.8 %), and Writer/Artist (18.3 %) appearing most commonly, followed by Multiple and Activists with 15.5 % each (Fig. 1).

Seventy-one different sustainability champions were named (Table 3). Eleven received multiple votes. Rachel Carson tallied the most votes with six, while Daniel

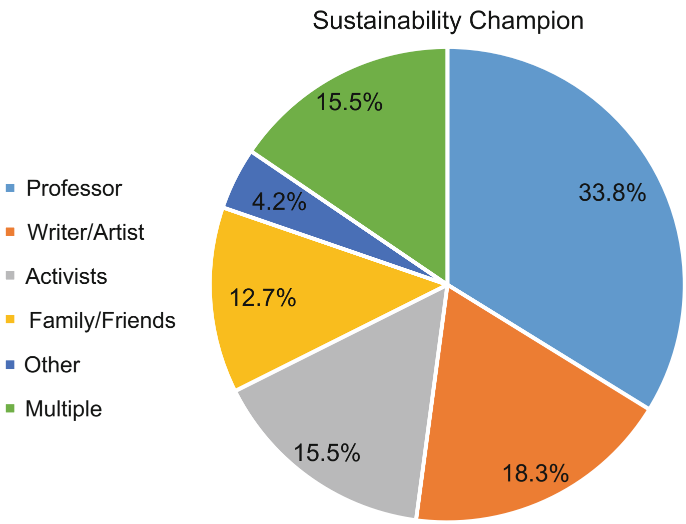


Fig. 1 Categorization of sustainability champions

Table 3 Complete list of named sustainability champions

Professor		Writer/artist	Activists	Multiple	Other
Arnim Wiek	Jacob Songsore	Adam Smith	Allan Savory	C.S. (Buzz) Holling	Dian Fossey
Brent Ward	James Scott	Aldo Leopold	Allyson Brady	Daniel Quinn	Noam Chomsky
Bruce Mitchell	John Gaventa	Buffy Sainte-Marie	Dalai Lama	David Schindler	Patricia Chambers
Cheryl Waldner	John Bennett	David Quammen	Fred Roots	David Suzuki	
David McCorquodale	Julian Agyeman	E.F. Schumacher	John Francis	Elizabeth May	
Douglas Clark	Lalita Bharadwaj	Garrett Hardin	Kelly Goyer	Fikret Berkes	
Edward Fife	Paul Nadasdy	Gary Nabhan	Kevin Davis	Jane Goodall	
George Francis	Robert Costanza	Gary Snyder	Lauren Singer	John Muir	
Graham Strickert	Sarah Coulthard	Ian McHarg	Nelson Mandela	Rachel Carson	
Helen Baulch	Supervisor (Unnamed)	Jared Diamond	Ron Gonen	Steve Irwin	
Herman Daly	William Gough	Julian Steward	Sheri Praski	Vandana Shiva	
Hugh Possingham		Midnight Oil	Wangari Maathai		

Identified individuals in the family/friends category were omitted

Quinn and David Suzuki had four votes each. Others meriting 2–3 votes included: Fikret Berkes, Jane Goddall, C.S. (Buzz) Holling, Steve Irwin, Elizabeth May, John Muir, David Schindler, and Vandana Shiva. Although it is not within the scope of this paper to provide detailed biographical analysis of each of the 71 sustainability champions, it is worth addressing the sustainability champion that received the highest number of votes.

With the most sustainability champion votes, Rachel Carson seemed to fit in several of our coded categories. Carson had a passion for writing and the natural world, especially the ocean. Her academic training and research mostly focused on marine biology. She promoted awareness of the marine environment during her tenure as a marine biologist through a series of books: *Under the Sea Wind* (1941), *The Sea around Us* (1951), and *The Edge of the Sea* (1955). These three instalments would eventually become known as the sea trilogy. She won the Borroughs Medal in nature writing and a U.S. National Book Award for *The Sea around Us* in 1952. Carson's early works did not receive the level of attention as her later pieces, but her awarding winning writing proved to be a key component in situating herself as a credible, established writer in the field of environmental science. The immediate environmental consequences as well as risks to human health from this application provided the impetus for her most significant book: *Silent Spring*. Published in 1962, *Silent Spring* initiated an environmental movement unlike any other, revealing the vast uncertainty surrounding the unregulated use of synthetic pesticides. *Silent Spring* forever changed U.S. and international environmental policy and subsequently, expedited the ban of DDT in the U.S., initiated actions to regulate the use of pesticides within and outside the U.S., and provided momentum to forming the U.S. Environmental Protection Agency.

Carson's background and work illustrates the influence, impact, and passion that connects with some affiliated with graduate sustainability education. One student found this connection apparent simply stating, "[her] mindset, passion, and skills allowed Carson to impact complex environmental issues". Other respondents added, "[her] work inspires me to keep exploring facets of the environment and how humans interact with it" and "[she] makes me question the world around me. Take a greater amount of time to think about things and observe". Carson's profound contributions to environmental literature have made her a significant figure in sustainability, continuing to inspire future generations with one student submitting, "the longevity of the impact created by Carson's work has resonated with me throughout my academic career".

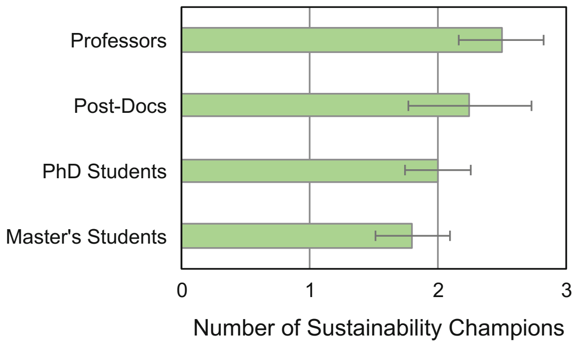
The survey data also demonstrated that sustainability champions do not have to be someone iconic to be inspiring, but can come from local sources. Most graduate students credited professors as effective sustainability champions. Two students added, "[they] made me want to pursue a graduate degree" and "I grew as a person…[through their teaching]". Non-local sustainability champions incited the same pattern of inspirational behavior. These findings suggest that professors wield significant influence in how they can affect sustainability curriculum and the practice of interdisciplinarity.

4.2 Do Sustainability Champions Change Over a Career?

Role models can serve as a critical purpose for students during their formative years (Bricheno and Thornton 2007). Findings from our survey suggested that sustainability champsions for students and faculty changed over time. Of the 47 responses, 53.6 % indicated their sustainability champion had changed during the course of their career. Survey respondents noted that, "As my interests and perspectives on the practice and values in sustainability change my champion changed". One student noted that," "I think openness and ongoing learning are important to achieving sustainability, and so I will (hope to be) continually be inspired by new people".

In the present study, we observed a difference in the mean of sustainability champions listed among the different academic groups (Fig. 2). On average, professors ($n = 8$) selected 2.5 sustainability champions (only one professor selected a single sustainability champion), post-docs ($n = 4$) selected 2.25, PhD students ($n = 12$) selected 2, and Master's students ($n = 16$) selected 1.8. While the data are not statistically significant, they were suggestive of an increase in the number of

Fig. 2 Mean (± SE) increase in the number of sustainability champions among students, faculty, and research staff



sustainability champions over time. This is a hypothesis that could be tested further in the future.

Participants who did not change their sustainability champion over time emphasized that their champions' lessons were enduring. For instance, one participant noted that, "their message is rather timeless". Similarly, another respondent noted that, "I've identified these three people because they provide foundational ideas that translate into multiple problems, settings, and solutions".

4.3 What Impact Do Sustainability Champions Have?

In response to the question (#7), "What impact does your Sustainability Champion have on your sustainability graduate education (student) or graduate teaching (faculty)?", Introduced New Ideas (n = 11, 28.2 %), Broader View (n = 10, 25.6 %), Inspiration and Motivation (n = 10, 25.6 %), were the three most represented categories, as indicated in Table 2. Measuring the influence or inspiration of any one individual does not provide us with a theoretical framework; however, the thematic analysis of responses contributed by survey participants can start a conversation.

There were notable differences between responses from professors and students. The majority of core faculty (n = 5, 71.4 %) reported Broader View as their selection criterion for their sustainability champion. For Broader View, one professor wrote, "I started graduate school with the notion of becoming a very conventional wildlife biologist. Taking classes with Fikret Berkes, and reading Buzz Holling, and Paul Nadasdy in detail helped me shift to a transdisciplinary approach that considers a much broader view of sustainability, using local and traditional knowledge, taking a practical and theoretical approach on working with communities and linking science with traditional and local knowledge". Similarly, another professor wrote, "[Holling, Roots, and Francis] have encouraged me to think broadly … beyond environment and to understand that sustainability must include social (incl. economic and cultural) dimensions". One professor specifically submitted that, "[fusing theory and practice] also guides the broader philosophy for

SENS, which is why it is a good fit for me to be part of this faculty." Potentially, this more expansive and inclusive thought process by professors could be an artifact of experience in sustainability education. Generational differences and background may play a role as well.

Students reported Inspiration and Motivation (n = 9, 35 %) and Introduced New Ideas (n = 7, 28 %) as the most common justification for their sustainability champion selection. For Inspiration and Motivation, one student wrote, "I've been encouraged to stay persistent, and truly believe that I'll be able to create positive change in the world, with regards to environmental sustainability". Another student wrote, "[Carson, Suzuki, Irwin] all got me started in the field, and their work inspires me to keep exploring facets of the environment and how humans interact with it". For Introduced New Ideas, one professor wrote, "Quinn in particular made me realize that the best way to teach sustainability is to focus on ideas and ways of thinking over technical knowledge or concepts". Some students had more specific responses, "It has me looking at how traditional practices could be reinstated to fix current 'conventional' methods of resource extraction". Most respondents recognized professors as their sustainability champion. This student identified "inspiration and motivation" mindset may be a guidepost for advisors, supervisors, or mentors to effectively impact students. As a role model, sustainability champions may play key roles in shaping attitudes, values, and ideals that fit our own, and may guide our thought process.

4.4 What Are the Links Between Sustainability Champions and Interdisciplinarity?

Our survey found that the majority of students (n = 23, 82.1 %) described themselves as interdisciplinary with only a minority as disciplinary (n = 2, 7.1 %), which was higher than the professors' response (n = 6, 75 %). Similarly, Rhoten and Parker (2004) surveyed graduate students and professors from five interdisciplinary university-based research programs. The percentage of graduate students involved in interdisciplinary collaborations was higher than the professors. About 62 % of graduate students reported a minimum of one interdisciplinary project while 49 % of professors indicated the same. Younger researchers or students appear to be more apt to contribute to interdisciplinary research and are searching for multiple means to establish themselves (Rhoten and Parker 2004). Although a subtle, circumstantial measure of interdisciplinary research potential, knowledge of career stage among project collaborators may prove useful moving forward to integrating interdisciplinary approaches to complex problems. To access the full potential of both sustainability science and interdisciplinary approaches, the future will heavily rely on education and interactions between young researchers familiar with this growing discipline (Raivio 2011). We feel these connections are important to consider when defining sustainability champions. Their ideas and inspiration continue to advocate for interdisciplinarity in sustainable development.

5 Conclusions

In this chapter, we investigated the role of sustainability champions in graduate sustainability education. Seventy-one sustainability champions were identified with eleven individuals named more than once. Among the individuals named, Rachel Carson received the most votes with six. Participants selected a variety of sustainability champions, including writers, artists, professors, activists, family, and friends.

Overall, our survey coarsely indicated sustainability champions come in two forms: classic pioneers and professors. While the iconic figures were not that surprising, what was surprising was the role of everyday professors. Our thematic coding methodology revealed 33.8 % of the 47 respondents indicated their sustainability champion was a professor. The selection of a classic pioneer or professor may have some relevance to the role the sustainability champion plays. For instance, respondents credited their sustainability champions with invoking different approaches to sustainability education. According to our data, sustainability champions can broaden the scope of a professor's career vision and may play an inspirational role for a student to develop interdisciplinary, sustainability skill sets.

Sustainability champions may also shift over time. When asked if their sustainability champion had changed over the course of their career, 53.6 % of respondents indicated it had changed, suggesting inspiration or openness to new sustainability champions can occur at any stage of our careers. Moreover, stage in career provided an important insight to number of sustainability champions identified; although not significant, there was an increase in the number of sustainability champions listed by respondents more advanced in their careers.

5.1 Future Implications

There has been much emphasis on the importance of role model education in the K-12 context, our data indicate that the concept of sustainability champions as role models may resonate into graduate education among faculty and students. Professors were designated as the most prevalent sustainability champion. Passionate educators exude inspiration. One student who identified a professor as a sustainability champion declared, "[he] taught me about the role of the individual, personal choice and trade-offs in sustainability. These themes continue to shape/colour the lenses through which I conduct my research and the choices that I make in my personal life". Students increasingly will be the agents of change when it comes to sustainability science. They will graduate to influence the next generation of thinking on the topic. Professors play a large role in inspiring these students. These same professors are influenced by both professors and more traditional icons associated with sustainability. An underleveraged resource in the future of sustainability education may be to recognize and reinforce the role professors play in providing inspiration and impact to their students. If students are to act as agents of sustainability and be tasked with the overwhelming complexity facing sustainability issues, professors must take equal responsibility and recognize themselves not only as educators or researchers, but as role models for practicing and advancing sustainability.

References

Anderson, B., Cutright, M., & Anderson, S. (2013). Academic involvement in doctoral education: Predictive value of faculty mentorship and intellectual community on doctoral education outcomes. *International Journal of Doctoral Studies, 8*, 195–201.

Barth, M., & Michelsen, G. (2013). Learning for change: an educational contribution to sustainability science. *Sustainability Science, 8*, 103–119.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Quality Research in Psychology, 3*, 77–101.

Black, E. W. (2008). Wikipedia and academic peer review: Wikipedia as a recognised medium for scholarly publication? *Online Information Review, 32*, 73–88.

Bricheno, P., & Thornton, M. E. (2007). Role model hero or champion? Children's views concerning role models. *Educational Research, 1881*, 1–22.

Bucher, A. A. (1997). The influence of models in forming moral identity. *International Journal of Educational Research, 27*, 619–627.

Cortese, A. D. (2003). The critical role of higher education in creating a sustainable future. *Planning for Higher Education*, 15–22.

Hunter, K. H., & Devine, K. (2016). Doctoral students' emotional exhaustion and intentions to leave academia. *International Journal of Doctoral Studies, 11*, 35–61.

Leal, W. F., Shiel, C., & Do Paço, A. (2015). Integrative approaches to environmental sustainability at universities: an overview of challenges and priorities. *Journal of Integrative Environmental Sciences, 12*, 1–14.

Leal, W. F. (2011). About the role of universities and their contribution to sustainable development. *Higher Education Policy, 24*, 427–438.

Nielsen-Pincus, M., Morse, W. C., Force, J. E., & Wulfhorst, J. D. (2007). Bridges and barriers to developing and conducting interdisciplinary graduate-student team research. *Ecology Society, 12*, 1–14.

Pooley, S. P., Mendelsohn, J. A., & Milner-Gulland, E. J. (2014). Hunting down the chimera of multiple disciplinarity in conservation science. *Conservation Biology, 28*, 22–32.

Raivio, K. (2011). Sustainability as an educational agenda. *Journal of Cleaner Production, 19*, 1906–1907.

Rhoten, D., & Parker, A. (2004). Risks and rewards of an interdisciplinary research path. *Science, 304*, 1251–1252.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., et al. (2009). A safe operating space for humanity. *Nature, 461*(7263), 472–475.

Rose, D. (2004). The potential of role-model education. In *The Encyclopedia of Informal Education*. Last Accessed January 20, 2016 http://infed.org/mobi/the-potential-of-role-model-education/

Roy, E. D., Morzillo, A. T., Seijo, F., Reddy, S. M., Rhemtulla, J. M., Milder, J. C., et al. (2013). The elusive pursuit of interdisciplinarity at the human—environment interface. *BioScience, 63*(9), 745–753.

Ryan, M. M., Yeung, R. S., Bass, M., Kapil, M., Slater, S., & Creedon, K. (2012). Developing research capacity among graduate students in an interdisciplinary environment. *Higher Education Research and Development, 31*(4), 557–569.

Steelman, T. A., Nichols, E. G., James, A., Bradford, L., Ebersöhn, L., Scherman, V., et al. (2015). Practicing the science of sustainability: the challenges of transdisciplinarity in a developing world context. *Sustainability Science, 10*(4), 581–599.

Steffen, W., Crutzen, P. J., & McNeill, J. R. (2007). The Anthropocene: are humans now overwhelming the great forces of nature. *Ambio, 36*(8), 614–621.

Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: A reference framework for academic program development. *Sustainability Science, 6*(2), 203–218.

Zare, R. N., & Metzger, N. (1999). Interdisciplinary research: From beleif to reality. *Science, 283*(5402), 642–643.

Renewable Distributed Generation and Its Stakeholders' Engagement Contributing to Climate Change Mitigation and Adaptation in Brazil Unisul—Universidade Do Sul de Santa Catarina, Brazil

Mario Corrêa de Sá e Benevides, Alek Suni and José Baltazar Salgueirinho Osório de Andrade Guerra

Abstract

The Brazilian electricity grid will likely continue to depend on hydroelectricity in the medium term. However, mainly because of severe droughts in 2013 and 2014 (as a matter of fact, the droughts started in December, 2012, and are still worrying Brazilians in the first quarter of 2015), renewable and non-renewable alternative sources are expected to grow. Some of the factors expected to spur small-scale, distributed generation (DG) are costs and socio-environmental impacts of expanding the national grid, the country's large, geographically diverse territory, and decreasing costs of renewable DG sources. Complementing the Brazilian electricity mix with renewable DG can contribute not only to climate change mitigation—by avoiding new GHG emissions—but also to climate change adaptation through economic and electric diversification. Indeed, economic diversification is one of the goals on the United Nations' Framework Convention on Climate Change (see U.N. Framework Convention on Climate Change). The authors noted in a previous article the lack of information in Brazil about photovoltaic energy and the role of the university promoting this concept (see Suni, Benevides, and Guerra). Now, they intend to demonstrate, besides DG's benefits to climate change mitigation and adaptation, how stakeholders' engagement in this field can improve the sustainability of DG and accelerate its adoption in the country.

M.C. de Sá e Benevides (✉) · A. Suni · J.B.S.O. de Andrade Guerra
University of Southern Santa Catarina, Santa Catarina, Brazil
e-mail: mariocsb@enstt.com

A. Suni
e-mail: alek.suni@fulbrightmail.com

J.B.S.O. de Andrade Guerra
e-mail: baltazar.guerra@unisul.br

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_21

Keywords
Climate change adaptation and mitigation · Renewable distributed generation · Brazil

1 Introduction

According to ANEEL, the Brazilian electric energy agency, by March 2015, solar energy accounted for only 0.01 % of the country's 135.2 GW installed capacity, and wind power for 4.18 %.[1] Due to the severe droughts beginning in December 2012 that continued to impact hydroelectric generation during 2013 and 2014, the government established highest energy cap prices for new wind and solar power projects. An auction held in October 2014 succeeded in adding a total of 1658.7 MW from 31 new wind power plants with 889.6 MW total capacity and another 31 new solar power plants totaling 769.1 MW. The average energy prices in these auctions were R$ 142.3 and R$ 215.00 respectively.[2] It is important to highlight that these projects are to be connected to the national grid.

2 Distributed Generation (DG) in Brazil

In Brazil, with its large territory, potential and needs of social-economic growth, besides the availability of primary sources such as water, wind, biomass, coal and oil, DG is seen as a complement to the country's electric energy matrix. In the beginning of 2015, DG is very underdeveloped and incipient in Brazil. There are two main reasons for this. First, even now, wind and solar equipment for DG are still expensive, needing to be imported[3]—but projects to produce this equipment in Brazil are underway.[4] Second, there is a lack of information, especially among consumers, about the possibilities of having an autonomous energy supply interchanging with a distribution company (DISCO). Favorable regulations for

[1]Hydro, thermo and nuclear power plants accounted for 66.31, 28.03 and 1.47 % resp. Source: http://www.aneel.gov.br/aplicacoes/capacidadebrasil/capacidadebrasil.cfm.

[2]According to BACEN—the Brazilian Central Bank—on Oct 31st, 2014, when the auction took place, the exchange rates were: EUR 1.00 ≡ BRL 3.06; USD 1.00 ≡ BRL 2.44; and GBP 1.00 ≡ BRL 3.91. On March, 14th, 2015, mainly due to a political crisis, the figures had changed to: EUR 1.00 ≡ BRL 3.40; USD 1.00 ≡ BRL 3.23; and GBP 1.00 ≡ BRL 4.76, corresponding to a depreciation of Brazilian currency of 11, 32 and 22 in 4.5 months, respectively.

[3]As referenced above, while this article is being written, the exchange rates in Brazil are unfavorable to imports, but this situation may be temporary, as it is due to the uncertainty of the aforementioned political crisis.

[4]Even in recent years, wind farm technology was uncompetitive in Brazil, while now there are competitive local industries, both national and multinational.

grid-connected DG systems like wind or solar photovoltaic (PV) power are relatively recent in Brazil, as the national electricity regulator began allowing connections and net metering in 2012.[5]

3 Renewable DG and Climate Change Mitigation

Table 1 below, adapted from the article *Comparison of greenhouse gas emissions (GHG) in the nuclear generation of electricity in Brazil with the other sources*,[6] shows a comparison between emissions during the life cycle of different sources of electric energy generation. As noted earlier, PV power generation represents zero emissions, and wind generation, 5.4 gCO_2/kWh_{el}, respectively avoiding 1256.6 and 1262.0 gCO_2/kWh_{el} of coal emissions. Meanwhile, nuclear generation, despite having the lowest emissions life cycle, cannot be considered for DG purposes.

3.1 A Trade-off Between Solar and Wind Solutions

Table 1 also indicates that wind generation's total life cycle emissions are about 20 % of PV's, despite emitting 5.4 gCO_2 for each kWh_{el} more than the PV's emissions. Additional factors such as solar incidence and wind regimes, besides costs of manufacturing, transportation and installation are necessary to a case-by-case trade-off analysis between solar PV and wind DG solutions, and lie beyond the scope of this article.[7] This article gives a higher emphasizes PV generation because of its incipient presence in Brazil, especially considering the country's favorable solar incidence.

4 Renewable DG[8] and Climate Change Adaptation

The economic benefits of electricity sector diversification are clear. Principally, decreased reliance on a single source of generation capacity mitigates risks to the electricity sector. In general, the sector's diversification is seen as a means of

[5]See ANEEL Resolution 482/2012.

[6]See *Comparação da emissão de gases de efeito estufa (GEE) na geração nuclear de eletricidade no Brasil com as de outras fontes*, Economia and Energia (E&E), year XV, number 79, from October-November 2010. Available on http://ecen.com/eee79/eee79p/gases_nuclear.htm.

[7]In terms of sun irradiance and wind potential, Brazilian territory mostly presents satisfactory to very satisfactory conditions to both solutions individually, as well as in combination.

[8]From now on, the simple acronym DG denotes renewable distributed generation, or renewable DG.

Table 1 Direct and indirect emissions in electricity generation (gCO_2/kWh_{el})

Life cycle step	Nuclear	Coal	Bagasse	Diesel	Fuel oil	Wind	PV
Upstream	19.1	7.4	49.0	76.3	66.1	15.4	105.0
Generation	0.8	1262.0	*	755.0	725.0	5.4	0.0
Downstream	7.8	0.2	*	0.4	1.3	*	*
Marginal	0.1	76.3	0.0	0.0	0.0	0.0	0.0
Total	27.8	1346.0	49.0	832.0	792.0	21.0	105.0

*Not available

improving energy security, especially given solar PV production's similar characteristics to electricity demand.[9]

As previously mentioned, Brazil's overreliance on a single source has left the country vulnerable to weather volatility. As increasingly drastic weather patterns such as droughts are frequently linked to climate change,[10] a central strategy of climate change adaptation in countries with undiversified electricity mixes must address this reality. Solar and wind energy, which exhibit generally complementary output to hydropower,[11] represent suitable supplements to the principal hydropower sources in Brazil and provide this means of adaptation.

When diversification is pursued via intensified use of distributed solar PV, there are also inherent economic benefits in the transfer of generation capacity to small-scale stakeholders. Peak use savings, ease of siting near consumption areas, and mitigating risks from incidents at larger production centers all present DG, particularly through solar PV, as a favorable economic and environmental alternative to current generation paradigms.[12] Because siting of DG via individual solar PV installations shortens the distance between production and consumption, DG scenarios preclude the need for long-distance transmission infrastructure. One International Energy Agency (IEA) estimate projects overall savings of 30 % on average from DG over conventional utility-scale generation.[13] In Brazil, where electricity tariffs are high, widespread installations on homes and businesses would reduce transmission costs by obviating future transmission lines to planned hydropower plants. Therefore, while diversification can occur in either a utility-scale or DG context, the latter provides better cost savings potential and safeguards against blackout risk.

[9]See Johansson.

[10]See Frich et al.; Rosenzweig et al.

[11]See Traca de Almeida et al.

[12]See Pepermans et al., Farrell, Lovins et al.

[13]See Pepermans et al.

5 Successes with DG in Other Countries

5.1 In Europe

European countries have led the rest of the world in DG initiatives and total installed solar PV in recent years. As of 2013, six of the top ten countries in installed PV capacity were European—Germany, Italy, Spain, France, Belgium, and the Czech Republic.[14] Much of the installed PV capacity in Europe is in a DG context of rooftop systems for homes and small businesses. In Germany for instance, which makes up almost a third of world PV capacity,[15] DG represents 48 % of the national electricity grid.[16]

Despite the continent being generally unfavorable for PV generation, concerted policy efforts to spur installations have been demonstrably successful. Such policy pushes are particular to wealthier countries like Japan, the US, and in Europe, where there is greater fiscal leeway for costly renewable energy support mechanisms. Similar efforts are understandably less reproducible in developing countries like Brazil, where public funding for social programs and infrastructure take precedence as economic development priorities.

5.2 In the US

In the US, the majority of solar energy is utility-scale, connecting larger solar PV parks with consumers through conventional means of distribution. While not rivaling places like Germany in small-scale rates of installation, areas of the US with higher insolation and state-level financing or subsidy schemes are incipient and promising.

Despite pushback from some utilities arguing against "free-rider" policies of allowing residential producers grid access, compromises have been reached through moderate connection fees.[17] This creates marginally higher DG solar costs, but without endangering the utility transmission model that characterizes the US grid.

Rapidly falling domestic prices of wind and solar electricity sources in recent years have facilitated transitions to renewable sources in the US. Both sources, when compared previously against conventional coal-burning generation, faced insurmountable economic obstacles to implementation. More generous government support mechanisms and renewable electricity mandates in at least 29 states[18] have quickened the pace of investment in both utility-scale and distributed renewable generation.

[14]See BP Statistical Review of World Energy.

[15]See BP Statistical Review of World Energy.

[16]See Ernst and Young.

[17]See Navigant Research.

[18]See Institute for Energy Research.

Recently, politics have also played a role in diversification. In the wake of the Great Recession, arguments for coupling emissions reduction efforts with economic recovery prevailed in the economic policymaking circles of the Obama Administration. Recovery stimulus was shunted to renewable energy initiatives deemed to create jobs through installing rooftop PV systems and expanding renewable production. To be sure, total employment generated by these initiatives is difficult to quantify,[19] and many independent estimates indicate green job creation in response to the Great Recession fell short of officially touted predictions.[20]

The political support garnered for alternative renewable sources nonetheless aided in spurring installations beyond the limited scope under normal market conditions. Regardless of the impact on employment, the economic benefits of diversification are undeniably applicable in the context of renewable energy resource development. Installed wind capacity in the US increased over 70 % between 2009 and 2012, while solar PV grew by over 350 % over the same period, albeit from a smaller base.[21] Overall, trends toward a diversified energy portfolio in recent years have contributed to a decline in US emissions. Notably, much of the observed emissions reductions are attributed to increased use of natural gas in lieu of coal, rather than from use of distributed solar or wind sources.

6 Stakeholders' Engagement

Engaging stakeholders surpasses the traditional approach of conquering customs with good workers and suppliers. Its reach goes beyond the number of actors, and engages in more than simply knowledge, consulting or even involving people. Day after day, society increases its interconnectivity around the world. For example, a large hydropower plant undertaking in Brazil is discussed not only locally, but also in a variety of global forums. This means that an analysis concerning stakeholders of such enterprise will include both local and nonlocal communities, albeit in different levels and with different interests, in addition to suppliers, contractors, labors, etc. With respect to DG, it would be a mistake to think that the engagement of stakeholders does not apply.

[19]See Romero.

[20]See Muro et al.

[21]See BP Statistical Review of World Energy.

7 Methodologies

There are several stakeholder engagement methodologies. One of them is Jacques M. Chevalier's CLIP[22]—an acronym for collaboration and/or conflict, legitimacy, interests and power. CLIP consists of the following:

- Identify the subject that requires this kind of analysis—an undertaking, action or situation—and its stakeholders;
- Evaluate each stakeholder's power, resources and expectations, and whether they are supposed to support or oppose the subject, aside from their legitimacy and interests (high, medium or low);
- Map them, including their relationship with the subject and among themselves.

Finally, a stakeholder analysis has to establish strategies to keep a reasonable relationship with and among all of them, approximating those who may effectively contribute to the subject's objectives, in an ethical, mutually beneficial basis.

8 How Stakeholders' Engagement Can Help Accelerate the Adoption and Improvement of Sustainable DG

8.1 Stakeholders' Mapping

Table 2 shows a simplified mapping of relevant stakeholders as a strategic approach to DG solutions in Brazil. This simplification has considered that: (a) from a general point of view, in different levels and ways, all stakeholders are interested in DG; and (b) the relationship among them is implicit.

8.2 Stakeholders' Engagement Accelerating the Adoption of DG

Table 3 suggests strategies of stakeholders' engagement from the point of view of each stakeholder shown in Table 2.

8.3 Stakeholders' Engagement Improving the Sustainability of DG

Efforts to engage stakeholders, especially based on transparency, proactivity and innovation, can be a powerful tool to accelerate good initiatives in a sustainable way. Stakeholders' engagement can contribute, for instance, to eliminating poor

[22]Available on www.sas-pm.com/SAS/sa tech.htm.

Table 2 DG stakeholders' mapping in Brazil

Stakeholder	Basic expectations	Power	Interest	Legitimacy	Comments
Government	Diversify the energy matrix	High	High	High	In national and local spheres
Suppliers	Increase their sales	High	High	High	Both national and international, competing or developing partnerships
Consumers	Decrease their electricity bills	High	Moderate	High	Low levels of knowledge about DG and DG's still low competitiveness
DISCOs	Diminish their investments to expand their grids, without losing incomes	Moderate	Moderate	High	Inertial behavior to an innovation and doubts about gains and losses
Power generation companies	Diversify their business	High	High to moderate	High	Used to long-term return on investments, and high capacity for project finance; on the other hand, they may experience difficulties determining how to act on a decentralized basis
Society	Mitigate and adapt to climate changes	Moderate	Moderate to low	High	Low levels of knowledge about DG and climate changes
Sustainability forums	Mitigate and adapt to climate changes	Moderate	High	High	DG is seen as clean energy
Academia	Spread new, clean technologies	High	High	High	A good experience in Latin America is described in the sequence of this article

Table 3 Suggested stakeholders' engagement strategies

Stakeholder	Suggested strategy to accelerate DG adoption	Suggested strategy to other stakeholders' engagement
Government	Tax incentives for production	Transparency, dialogue, consultation, promotion
Suppliers	Innovation in design, manufacture, trade, assemble and sales; long-term assistance to consumers	Establish networks and clarify short, medium and long-term benefits to the consumers
Consumers	Be informed of DG evolution and long-term benefits	Contact specialists
DISCOs	Be informed of DG evolution and long-term benefits	Proactivity, openness to dialogue
Power generation companies	Remain aware that the largest risk may be not taking part in DG	Offer funding and financing capacity, as well as technical and managerial skills
Society	Awareness of DG evolution and long-term benefits	Associative initiatives, dialogue, consultation
Sustainability forums	Divulge and clarify climate change and adaptation concepts, and recommend clear, feasible solutions	Intensify efforts to improve forum's effectiveness
Academia	Research, development and innovation, having pilot projects as a powerful *shop window*	Assume the role of promoting interconnections between the different players; partnerships with companies and among universities

working conditions in the value chain. It can also provide better knowledge about climate change and adaptation, and how DG—besides other measures—can contribute to these goals.

In addition to stakeholders exemplified in Tables 2 and 3, non-governmental organizations (NGOs) and the financial sector have very relevant roles promoting, educating and helping to engage people and institutions, in addition to obtaining and providing funding. In Brazil, especially in the Amazon, there are communities without electricity, or that produce power via diesel generators. This scenario of course falls outside Brazil's generally more sustainable electricity mix. Rural electrification programs in other large developing countries have had success with DG solutions, including in China and India,[23] where isolated PV systems and other DG were well received in communities[24] without the need for expanded transmission capacity.

In Brazil, prior policies to include rural communities were instituted beginning in 2003 with *Luz para Todos* (Light for All), which relied partly on DG solutions for rural electrification purposes, connecting over 11 million Brazilians to electricity sources.[25] Though the program also reached new customers through

[23]See Niez.

[24]See Blenkinsopp et al.

[25]See Gomez and Silveira.

expanded transmission lines, many have argued that electrification of the remaining disconnected rural communities will be most economical through DG.[26] In addition to economic and environmental benefits, DG can contribute to social inclusion and better quality of life for isolated communities, expanding access to communications, information, providing better conditions for schools, health centers and other facilities. In these cases, public-private partnerships may be necessary. As a counterpart, significant positive socioeconomic impacts can be achieved. Improving education, health and living conditions brings integration, better skills and working conditions, a better understanding of politics, economics and human rights, as well as education for a more sustainable coexistence with the environment.

8.4 The Role of the University—REGSA's Experiences in Latin America

Given a favorable outlook for DG in Brazil, the interaction of stakeholders can be facilitated through academic forums. While academic institutions can provide examples through pilot projects showcasing new net metering options for small-scale producers, they also serve a broader role in Brazil of increasing understanding of less-known policy changes. Conferences and symposia can serve to increase knowhow when each group is actively involved.

Groups like REGSA (Promoting Renewable Electricity Generation in South America) and similar academic consortia explore renewable energy solutions particular to regulatory paradigms and climatic conditions in different South American countries. This is particularly relevant in exploring possibilities for DG in rural or community development contexts often left out of large-scale actors' involvement in new policy paradigms affecting the electricity sector.

The most pertinent recent example of this is REGSA's own pilot program that served as an example for connecting a small consumer to the electrical grid by means of new net metering provisions in Brazil mentioned above. Initiatives of this variety serve to provide a more inclusive environment for renewable DG whereby smaller stakeholders are informed of and afforded the advantages of policy changes.

9 Conclusion

Renewable distributed generation (DG) can contribute to climate change mitigation and adaptation, avoiding GHG emissions and helping to diversify the economy and electric power production. In Brazil, DG can also provide complementary benefits to the country's electricity matrix, especially considering the Brazilian territory still has regions lacking electricity. The country is also characterized by heavily populated urban centers where DG, at least partially, may afford independence from

[26]See Niez; Instituto Acende Brasil.

and energy supply exchange with distribution companies. On the other hand, to think that stakeholders' engagement would not be necessary in DG would be an equivalent mistake to think that, at least presently, DG could completely substitute hydro and/or thermoelectric power generation in a large country as Brazil. In the authors' view, stakeholders' engagement in DG projects in Brazil can contribute to its adoption in a sustainable way, by means of social inclusion, quality of life, education and professional preparation in the country.

Acknowledgments This study was conducted as a part of two programs from the University of Southern Santa Catarina (Unisul): Energy Efficiency and Sustainability Research Group (Greens) and REGSA - Promoting Renewable Electricity Generation in South America -, in the context of the projects: Linkages between energy, food and water consumption in the context of climate change mitigation strategies (LINKS 2015), and Building Resilience in a Dynamic Global Economy: Complexity across scales in the Brazilian Food-Water-Energy Nexus (BRIDGE), funded by the Newton Fund, Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina and the Research Councils United Kingdom (RCUK).

References

ANEEL (Agência Nacional De Energia Elétrica). Brazilian Electricity Regulatory Agency. *Capacidade De Geração Do Brasil*. N.p., Web. http://www.aneel.gov.br/aplicacoes/capacidadebrasil/capacidadebrasil.cfm.

ANEEL (Agência Nacional De Energia Elétrica). (2012). Brazilian Electricity Regulatory Agency. *Resolution* N 482/2012. http://www.aneel.gov.br/cedoc/ren2012482.pdf

Blenkinsopp, J., Coles, S. R., & Kirwan, K. (2013). Renewable Energy for Rural Communities in Maharashtra, India. *Energy Policy* (2013): n. pag. Elsevier, Web.

BP. (2013). *Statistical Review of World Energy 2014*. N.p., June 2013, Web. http://www.bp.com/statisticalreview

Ernst & Young. (2013). Distributed generation hits the big numbers. *Utilities Unbundled*, n. pag. December 2013, Web.

Farrell, J. (2011). Democratizing the electricity system: A vision for the 21st century grid. *The New Rules Project*. www.newrules.org

Frich, P. (2002). Observed coherent changes in climatic extremes during the second half of the twentieth century. *Climate Research* 19, (n.d.): n. pag. 2002, Web.

Gomez, M. F., & Silveira, S. (2010) Rural electrification of the brazilian amazon—achievements and lessons. *Energy Policy, 38*(10):6251–260, Elsevier, Web.

Johansson, B. (2013) Security Aspects of future renewable energy systems—A short overview. *Energy*, n. pag. Elsevier, Web.

Institute for Energy Research. The Status of Renewable Electricity Mandates in the States. Rep. N. p., n.d. Web. http://www.instituteforenergyresearch.org/wp-content/uploads/2011/01/IER-RPS-Study-Final.pdf

Lovins, A. B., & Datta, E. K. (2002). *Small is profitable: The hidden economic benefits of making electrical resources the right size*. Snowmass, CO: Rocky Mountain Institute.

Navigant Research. (2014). *Global Distributed Generation Deployment Forecast*. N.p., Fall 2014. Web. http://www.navigantresearch.com/research/global-distributed-generation-deployment-forecast

Pepermans, G., Driesen, J., Haeseldonckx, D., Belmans, R., & D'haeseleer, W. (2005). Distributed generation: Definition, benefits and issues. *Energy Policy, 33*(6):787–98.

Romero, J. (2013). Green Jobs: Not a Black and White Issue. U.S. Federal Reserve Bank of Richmond, Web.

Rosenzweig, C. (2001). Climate Change and Extreme Weather Events. *Global Change and Human Health,* 2(2):90–104 (Springer, Web).

Jon, S., & Toman, M. (2010). *Green Stimulus, Economic Recovery, and Long-Term Sustainable Development*. The World Bank, Web.

Suni, A., Benevides, M., & de Andrade Guerra, J. B. S. O. (2014). *The Role of the University in Promoting Photovoltaic Usage in Brazil*. Springer, Web.

Traca De Almeida, A. (2007) Source reliability in a combined wind-solar-hydro system. *Power Apparatus and Systems*, February 2007, Web.

U.N. Framework Convention on Climate Change, N.p., n.d. Web. http://unfccc.int/adaptation/items/7006.php

A Holistic View for Integrating Sustainability Education for the Built Environment Professions in Indonesia

Usha Iyer-Raniga and Tony Dalton

Abstract

Emerging economies in Asia and Latin America face rapid urbanization and city building in the next few decades. The existing work force and the next generation of built environment graduates play a significant role in lowering carbon emissions as a result of rapid building and infrastructure now and in the future. A range of disciplines comprises the built environment professions, and these disciplines need to work collaboratively to optimize design, construction and operational impacts. Amongst a range of issues identified in the literature in the move towards low carbon economies for built environment professions include technical know how, appropriateness in applying climate sensitive design, demonstration examples and case studies, silo-mentality amongst the disciplines, lack of support within universities to make change, lack of up to date resources, lack of true "lessons learned" of building operation post occupancy, lack of professional development amongst educators, lack of industry input in the curriculum, and lack of opportunities to make changes to the existing curricula (Iyer-Raniga and Andamon 2012, 2014). In this context, this chapter reports on key challenges facing the architectural education and architecture profession in Indonesia. Using desktop reviews, and semi structured interviews with academics, industry, government and peak industry bodies in Indonesia, this chapter provides an analysis of the architecture profession and architectural education in Indonesia. This analysis was undertaken to understand what are the current barriers preventing the architecture profession in Indonesia towards

U. Iyer-Raniga (✉)
School of Property, Construction and Project Management, RMIT University, Melbourne, Australia
e-mail: usha.iyer-raniga@rmit.edu.au

T. Dalton
School of Global, Urban and Social Studies, RMIT University, Melbourne, Australia

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_22

adopting low carbon principles in its design, construction and operation. Technical know how, supported by resource and case studies alone are not sufficient to embark on a journey of change to meet the needs of a sustainable future. A deeper analysis of the issues facing the architecture profession in Indonesia showed that knowledge alone is not sufficient; engagement and commitment from a range of stakeholders is needed. The chapter demonstrates that to embed lasting and holistic changes to architectural education, there needs to be a critical understanding of not just professional development needs for educators and industry practitioners, but also an awareness and understanding of institutional frameworks and networks that shape the profession. It provides a critical insight in shaping the architecture profession so key drivers may be identified along multiple dimensions, not just on maximizing professional development opportunities for academics and industry practitioners. This chapter provides a pathway for other built environment disciplines in transitioning economies to consider in shaping their own needs, and charting their own directions towards a low carbon future.

Keywords

Education · Built environment · Sustainability · Climate change · Green building · Low carbon · Architecture · Asia pacific · Indonesia

1 Introduction

Education for sustainability has long been recognized as critical for the future particularly in Europe and North America (Scott and Gough 2006; Lozano García et al. 2006; Stevenson et al. 2013; Yarime et al. 2012). While work in sustainability education has been undertaken in some Asian countries, notably in Japan (Nomura and Abe 2011), there is still a lot of work to be done in the lesser developed economies of Asia. As the emerging economies of Asia and Latin America engage in rapid city building activity, it is critical that the trajectory they are on, is one that is on a sustainable path, as, if this were not to occur, unsustainable practices will be 'locked in', resulting perhaps, to a point of no return.

Rapidly growing cities in some parts of the world emphasise the challenges of urbanization. The inclusion of the state of cities and their place in global discussions has received media attention, awareness and discussions relatively recently. In a World Bank report (Hoornweg and Freire 2013), it was shown that percentages of urban population will continue at current pace in Asia by 2050 and will comprise of about 55 % of global figures. The figures for Latin America and Europe are expected to fall and comprise only 10 % of global shares respectively, for the same period. Africa's urban population is expected to rise from current figures of just over 10 % to that of 20 % of global numbers.

Urban areas are high energy consumers. Energy, building and transportation are responsible for the bulk of global greenhouse gas emissions. Urban electricity, heating and cooling comprise 37 % of global energy-related emissions; buildings contribute 25 %, and urban transportation contributes 22 % (Baumert et al. 2005). Buildings in particular are responsible for 40 % of the world's energy use (UNEP 2009) and associated carbon emissions.

With the rapid urbanization of cities in Asia, the total emissions from buildings are also expected to increase. What is more, as buildings continue to operate, they 'lock in' bad or good design and technical characteristics over their life times. Hence, if designed and operated well, buildings can provide opportunities for reducing energy consumption through careful selection of materials (low embodied energy), equipment and appliances over their operation phase. At the start of the green building movement in the nineties, commonly held views about green buildings were that they were costly to build and therefore, economically not viable. The drivers for the green building movement were not economic incentives, but driven by social sustainability considerations such as corporate social responsibility. However, recent studies show that green building no longer costs more in some countries (Fitch and Laquidara-Carr 2013), especially where green building has now become the norm.

It is possible to align green outcomes with high economic activity. Taking this approach of aligning growth with sustainability outcomes have been instrumental in agreements leading to the recent outcomes for the COP 21 in Paris in 2015. For example, the World Bank states (Hoornweg and Freire 2013, p. 4):

> Green growth refers to making growth processes more resource efficient, cleaner, and more resilient, without necessarily slowing them (Hallegate et al. 2011). The focus is on what must happen over the next 5–10 years, before the world gets locked into patterns that would be prohibitively expensive and complex to modify. The short and the long term can be reconciled by offsetting short-term costs and maximizing synergies and economic co-benefits, green growth "shifts the production frontier by promoting innovation and harnessing potential synergies across sectors" (Hallegate et al. 2011). Green policies that can be used to capture these co-benefits include price-based policies, norms and regulation, public production and direct investment, information dissemination, education and moral suasion, industrial policies, and innovation policies.

The building sector is highly fragmented; there are several disciplines that encompass the building industry. Different disciplines are involved in the planning, design, construction and operation of buildings. There is an up front cost associated with green building, which the owner/developer pays for, but is not necessarily passed on to the tenant/occupiers of the building. Due to the functional differences in green buildings, technical knowledge, particularly best practice knowledge and 'testing/learning' of this knowledge may not be captured for the benefit of the industry. Thus, costs associated with green building and ongoing benefits needs to be communicated to the industry. This is where education can play a key role.

Link between education and the skills required for the burgeoning middle class of the Asia Pacific region is fairly weak. Investment in education is critical in driving greater productivity, growth and technological development. The underlying foundational argument is that high level skills for research and innovation is required for the labor market, which in turn, needs to be sustained by higher education that delivers skills for growth and innovation. In another recent World Bank report (World Bank 2012), it is clear that part of the problem is associated with a disconnection between the role of universities as systems and the actors that interact with universities. Universities operate as systems with little or no interaction with the wider world around them, leading to poor performance and poor outcomes for all concerned. In particular, the authors of the World Bank report posit that five disconnects can be observed (p. 2):

- gaps between higher education institutions and the skill needs of employers
- weak research and technology nexus between higher education institutions and companies
- separation between teaching and research functions
- lack of connectivity between the higher education institutions themselves
- disconnect between higher education institutions and feeder institutions.

What is commonly found in the countries in the Asia Pacific region is that there is generally a low capacity in higher education institutions; availability of poor information; weak incentives to gain more knowledge that have an impact on employers as well as companies that need growth and innovation to sustain and flourish. Furthermore, research institutions are needed to push the envelope for research and innovation, communication between the higher education institutions themselves and capacity for these institutions to train others and link the various classes of education with higher education.

This chapter focuses on Indonesia. The aim of the research was to identify the key drivers shaping the architecture profession so as to prepare architects for a future dealing with sustainability and climate change. In doing so, the barriers needed to be identified. The chapter presents the key challenges facing the architectural education and architecture profession in Indonesia by commencing with a desktop review. To understand the issues facing the various stakeholders particularly from an Indonesian context, semi structured interviews with academics; industry, government and peak industry bodies in Indonesia were undertaken. An analysis of the architecture profession and architectural education in Indonesia is then presented where the focus of the analysis is on highlighting current issues preventing the adoption of low carbon principles and practices. The results provide a critical insight shaping the architecture profession in Indonesia and point to key drivers that may be identified to maximize professional development opportunities for academics and industry practitioners.

The chapter commences with a background of the current situation in Indonesia. This is followed by current approaches used to deal with sustainability and climate change globally. The aim and approach to the research is then presented, with findings and discussions to follow. The future outlook for Indonesia is followed by the conclusions to the chapter.

Higher education is not just about formal university training leading to a prescribed qualification. It includes a range of training including formal and informal education that leads to degrees, diplomas, and professional certification. Higher education is linked directly to innovation and productivity and therefore well trained and highly educated workforce needs to be the foundational support for countries such as Indonesia. In this chapter therefore, higher education encompasses all formal and informal training.

So also, green buildings, sustainability and climate change are all used interchangeably. The emphasis is on the preparedness of the architecture and allied professions to meet an uncertain future focusing on rapid changes to new and existing built environment.

2 The Case for Indonesia

Indonesia is considered to be a middle income economy in South East Asia with GDP under US $7000 per capita (World Bank 2012, p. 8). Indonesia is largely an agri-based economy with a major share in assembling and processing electronic products. If Indonesia is to progress as an industrialized nation, it needs focus on moving to a manufacturing based economy. Indigenous industrialization has yet to occur in Indonesia for the country to become self sufficient with technological capabilities of other industrialized nations in the region such as Japan and Singapore.

The following point is used to illustrate the educational concerns for various professions in Indonesia, not just the built environment professions. As noted in World Bank (2012), from a sample of 12 Jakarta based firms comprising of services and manufacturing, it was found that the importance of education in the innovation process was quite varied. Pharmaceutical and wireless technology manufacturers indicated that a doctorate qualification was essential. Majority of the other respondents noted that a master's degree was sufficient and two of the firms reported that requisite skills were obtained through out-sourcing. Almost all firms (bar one) reported that industry specific technical knowledge and a broad understanding of the company's general operations were critical. Generic skills such as 'curiosity', 'proactivity', 'creativity' were critical for firms that had a commitment to research and development, and education.

In this chapter, skill development refers to a range of skills. It includes academic skills, life skills and technical skills. Academic skills usually focus on technical understanding and communication, and professional ethics and considerations. Life skills, often referred to as generic skills, refer to a broader set of skills, such as critical and creative thinking, problem solving, teamwork skills; what are called the "softer skills" relate to people interaction and management. Technical skills are associated with the professional nature of the job. So, for graduates in the built environment, technical skills would refer to understanding the process of building and construction, technical knowledge about building, operation and maintenance and such types of skills (World Bank 2012).

The World Bank report also states that Indonesia needs to focus on improving graduate quality and inclusiveness while building research capacity in a few universities. The focus to move towards a higher Gross Domestic Product (GDP) economy has been on IT services, finance, business, transport, telecommunications and trade. The built environment has been largely left out of the equation in Indonesia.

3 Sustainability, Climate Change and Higher Education

Generally, efforts worldwide dealing with sustainability have commenced with energy reductions and focused on how may we achieve collective action for reducing energy use. Sustainability considerations gained momentum post the Rio conference in 1992, moving from energy to holistic issues connected with the built environment. Following the release of various Intergovernmental Panel on Climate Change (IPCC) reports, recent foci have moved to climate change and the implications of a warming planet on a range of issues from ecosystem and anthropogenic health, to the built environment.

A common practice observed anecdotally amongst university academics is that when discussions of sustainability integration in the curriculum take place, the focus is always on the content of what needs to be taught. This is often in conflict with the senior management of the educational institutions, academic peers, and industry accreditation bodies' to name a few. As Tilbury (2011) notes, to bring changes for sustainability in academia long term commitments are needed, and these commitments need to become a part of the core business of higher education. It requires higher educational institutions to transform themselves, in turn, requiring strong leadership. The sustainability journey needs to be an interdisciplinary, participatory pedagogy, bringing in real world research and linking universities with the real world. These ideas require a systemic view of sustainability across various institutions to transform the educational experience.

Tilbury (2011) posits that research in sustainability education needs to move from a discipline focus to research that is inter and multidisciplinary. It needs to shift focus from purely academic impact to social impacts; from information to transformation; from technological and behavior change to research on social and structural change; and the researcher needs to move from being the expert to researcher as partner, and finally from research on people to research with people.

Higher education is not fully across the nature of the sustainability challenge. First, is the disconnect between learning *about* sustainability and learning *for* sustainability (Iyer-Raniga and Andamon 2016; Sterling 2004; Sterling and Thomas 2006; Thomas 2004). Despite more than a decade of discussions, most of the learning about sustainability still focuses on 'arm chair theorists' pontificating about what needs to be done, rather than demonstrating practical examples/applications and 'walking the talk'. The emphasis for sustainability is not just on the 'see and learn', but also on how the theory can be converted into practice. Demonstrating and 'walking the talk' focuses on learning for sustainability. There exists, therefore, a gap between expectation and reality.

Sterling and Thomas (2006) discuss the role of capability in guiding higher education curricula and demonstrate that most universities focus on sustainability through a 'bolt-on', or 'build-in' approach leading to no real integration within the curriculum. Integration into the curriculum requires more effort; it requires not just a focus on the content of the curriculum; it also needs to focus on engaging with academic peers, industry and government. To achieve true sustainability transition, it is essential to re build and re design courses and programs to be wholly integrated for sustainability education. Such approaches require fundamental changes, not just superficial changes. It needs to be embedded into how universities operate and how sustainability and climate change may be taught in universities. A relatively easier approach has been to focus on the content of sustainability in the courses and programs.

Outside academia, international organizations such as the United National Environment Programme—Sustainable Buildings and Climate Change Initiative (UNEP–SBCI) have been involved in linking policy outcomes with on-the-ground approaches for promoting sustainability in the built environment. UNEP-SBCI has been instrumental in linking policies by setting practical programmes such as the SPoD project (Sustainable Building Policies in Developing Countries) (UNEP-SBCI 2012). SPoD provides a methodological framework to countries and local authorities in developing countries that wish to define and set up an energy efficient buildings policy. It has elaborated a 4-step Quick Scan tool for such a policy comprising goals, barriers, content and system of authorities (see for example, http://www.unep.org/SBCI/QuickScanTool/index.html).

In a recent project on integrating sustainability education for engineering and built environment professions in the Asia-Pacific, Iyer-Raniga and Andamon (2012, 2014, 2016) show that focusing on the content of the curriculum alone is not enough to make changes to curricula. Among a range of issues identified are lack of support within universities to make change, lack of up to date resources, lack of true "lessons learned" of building operation post occupancy, lack of professional development amongst educators, lack of industry input in the curriculum, and lack of opportunities to make changes to the existing curricula.

At a more pragmatic level, the landscape is further complicated as there is a lot of 'green wash' that comes in the way of communication and understanding. For example, definition of zero energy buildings itself are unclear, leading to confusion and "green wars" in the market place. Buildings that call themselves zero energy buildings may not balance their energy supply with energy demands, whilst ensuring that energy needs are greatly reduced (Torcellini et al. 2006). This leads to a lot of confusion and misunderstanding. It is critical to read the fine print to understand what claims the building owner/s are making. Claims made about green building design performance may not match with the actual building performance, and this gap still needs to be bridged in the market place.

Beyond the rhetoric of triple bottom line (TBL) sustainability, recent changes with severe climatic events have also raised issues about how adaptation and resilience may be linked to university education. In the architecture field in Australia, Snow and Prasad (2011) demonstrate that capacity across the board for a range of known and unknown impacts is critical. This is particularly more so as the insurance industry and regulators are working towards determining risks to buildings and infrastructure at more detailed levels. Practitioners require additional skills for retrofitting and designing buildings for reduced liabilities for a range of weather impacts from heat waves/cold waves/forest fires, flooding, storm surges and natural events such as earthquakes, tsunami and volcanic eruptions. Examples of such events are expected to increase more in the future (CSIRO and Bureau of Meteorology 2015).

Sustainability and climate change do not have geographical boundaries. As a result, the role of collective action towards one common goal becomes critical. All countries and economies need to work collectively, therefore, to achieve common goals of a sustainable future for all. Authors such as Keohane and Victor (2011) discuss the difficulties in achieving collective action due to fragmentation of agencies and governments, where ‘the structural and interest diversity inherent in contemporary world politics tends to generate the formation of a regime complex rather than a comprehensive, integrated regime’, (p. 7) and argue for more focused and decentralized activities to achieve a bigger impact. They suggest that a more competitive system with a multitude of rules would be more effective. They also suggest that innovation, a range of different approaches (regimes) would offer opportunities for actors (in the current context of the paper, the building industry and its stakeholders) to work out the best approaches that suit them, including flexibility for cooperation on a range of different topics.

Another method is taking an institutional approach to understand how the various actors/stakeholders may interact or not with each other impeding collective outcomes for delivering sustainability and other linked goals. From this perspective, institutions may be considered as socially devised norms that shape human interaction (North 1990). Both formal and informal arrangements define institutions and guide human interaction (North 1994). As distinct from organizations, according to North, institutions are a set of rules, where organizations strategize to apply a set of rules to their advantage.

There are many examples of institutions that facilitate certain fundamental workings of our society. Universities may be considered as institutions that need to reassess their workings so as to meet outcomes from a sustainability perspective. Connor and Dovers (2002) use North’s thesis for operationalizing the idea of institutional learning for Australia in the context of sustainable development and test this on specific case studies. They use this as ‘vehicles’ for discussions on institutional change for Environmentally Sustainable Development (ESD) in Australia. The research presented here takes this underlying approach of going beyond curricula in universities to a more holistic approach, examining all stakeholders involved in delivering sustainable outcomes for the built environment. The aim and approach are presented below.

4 Aim and Approach to the Research

The current landscape in relation to the gap between sustainability and climate change education and practice has been presented, in particular, in an emerging economy such as Indonesia where there is a clear urgency in taking a decarbonized approach to city building.

To assist universities to bring sustainability and climate change knowledge into the mainstream, it is essential to understand the nature of how the built environment curriculum operate in Indonesia, but more importantly, the relationships between each of the disciplines comprising the built environment professions, and between industry and practice. Industry engagement is critical, as case studies and examples of best practice needs to be brought into the curriculum so that learning outcomes are contextualized in the real world. It is also essential to understand the current drivers and barriers supporting or hindering engagement so as to fast track towards the development of a robust curriculum.

To understand these complex issues, taking a stepped approach is critical. Previous research undertaken for integrating sustainability into built environment curricula showed that making changes to the curriculum is a good starting point (Iyer-Raniga and Andamon 2014, 2016). But this alone is not enough. Resources need to developed appropriately and industry stakeholders need to be involved in ensuring currency of information. Accreditation requirements for the built environment professions need to be contextualized within a country. The accreditation requirements for each of the built environment professions also vary from each other.

It was decided therefore, to take one built environment profession and undertake a more thorough analysis of this profession; to take a 'deeper dive' to understand the issues relating to the profession, and the sustainability and related implications of this particular profession. The architecture profession was the focus for a number of reasons. Anecdotal evidence demonstrates that the buildings built in Indonesia over the last decade are not responding to the challenges of climate change and sustainability. Buildings are still being predominantly built with glass and steel, with no consideration of climate sensitivity. Likewise, buildings are not being operated to minimize energy use, which is directly related to the design of the building and the prevailing regulatory landscape.

A desktop review assisted in developing a set of questions to undertake detailed semi-structured interviews with a range of industry and academic stakeholders. Purposive sampling was used, and the following were targeted as indicated in Table 1. A dozen or so respondents were targeted initially, and the list of stakeholders interviewed totaled fourteen.

The semi structured interviews were guided by the following questions for all stakeholders:

Table 1 List of stakeholders interviewed

	Code	Stakeholder and professional association
1	JS	Academic and as industry practitioner
2	BB	Architecture peak body
3	PT	Practicing architect
4	NA	Green industry body
5	PY	Green industry body
6	BS	Academic and senior manager
7	RN	Industry practitioner
8	IM	Academic and president of academic/industry body
9	NB	Green consultant
10	RS	Academic curriculum developer
11	TB	Government servant and consultant
12	EE	Academic and researcher
13	AA	Academic, researcher and senior university manager
14	AS	Stakeholder and civil society

(a) The projected demand for the architecture profession and future trends?
(b) The numbers of schools/universities/departments of architecture and its relationship with the other built environment disciplines: architecture, engineering, planning and others.
(c) The relationship between the architecture profession and other professions in other Asia Pacific countries and the plans for the future development of these relationships.
(d) The relationship between the development of building regulations by government and the architectural curriculum development.
(e) An understanding of the contemporary debate about future directions for the development of curricula for the architecture profession.

Specific questions on the architecture curriculum were also posed:

1. The history of the Department of Architecture within the broader history of university. Related questions on the history of the architecture program and its development into the current form, either as a department of architecture in its own right or part of engineering.
2. Details were also sought on
   - Under graduate and post graduate
   - Number of years/semesters
   - Student specializations
   - Relationship to other degrees e.g. interior architecture, engineering
   - Number of students.

3. The main influences on the development of the curriculum. Key factors that influenced the curriculum. Responsible body for curriculum development, review and renewal.
4. The cycle for curriculum review, renewal and accreditation. The processes for program accreditation and the body/ies responsible for accreditation.
5. The relationship between current knowledge of sustainability in architecture and more traditional concepts of building science, thermal comfort, passive architecture and bio climatic architecture.
6. The main ways of teaching architecture to students. Identification of the main teaching modes in terms of
   - Studios
   - Lecture and tutorials
   - Internships or placements in architectural practices and other workplaces
   - Exchanges with other universities in Indonesia and internationally.

7. An understanding of the size and scope of the teaching staff, such as;
   - Number and academic levels—lecturer to professor
   - Qualification levels
   - Staff histories in terms of where they undertook their degrees
   - Specializations of staff such as, history, theory of design, building science, urban design etc.
   - Workload expectations on staff in term of: teaching; research; community service; and private practice?

8. Existence of interdisciplinary teaching between the built environment professions and the nature of this teaching, where appropriate.
9. External relationships of the department/faculty with outside organizations? The main relationships in the following areas:
   - Industry
   - Professional associations
   - University sector.

10. The use of English in architecture teaching and learning.
11. Ranking of departments/schools of architecture in Indonesia.

Where stakeholders interviewed had a background other than architecture, the relationship between their professional association and architecture was explored. All bar one had a background in architecture.

Ethics clearance was obtained for the interviews from the Commonwealth Human Ethics Advisory Network in Australia. The interviews were recorded. All participants signed the consent form. The interviews lasted a minimum of one hour, and sometimes went as long as an hour and a half, based on the interviewee's willingness to participate and volunteer information. The interviews were transcribed, and most of the interviews took place over December 2014. Some of the interviews were undertaken on Skype with follow up in person during subsequent visits to Indonesia.

Due to the numbers of interviews the analyses were undertaken using key words from the transcribed interviews. An excel spreadsheet was used to note the key issues. These were then compared with the findings of the desk top review.

The findings of the interviews and its relationship with the literature cannot be generalized beyond the context of Indonesia. They may not provide conclusive evidence, but they demonstrate the need to consider a holistic set of issues as explained in the findings and discussion section. A further limitation is that all the participants communicated in English even though it was not their first language. Every care was taken to ensure that the interpretation was as the interviewees intended.

5 Findings and Discussions

There are many facets to the current problems of urban growth in Indonesia. Through the interviews and as reported in the literature, these are presented from five main perspectives, which formed the framework for the interview questions. These are contemporary issues facing the architecture profession in Indonesia, educational concerns, the role of other built environment professionals and the regulatory landscape.

5.1 Contemporary Issues Facing the Architecture Profession

The main points arising from the interviews are set below. They are not in any order of priority. They set out the breadth and depth of issues covered through the interviews.

- The peak professional body of the architects is the Institute of Architects. Institute of Architects has a say in the architecture curriculum.
- The Institute of Architects was formed in 1959, comprised mainly of graduates from Germany. There are roughly 15,000 members, of which 3000 are non-professional members.
- There are 3 categories of membership; basic, medium and advanced. The hours associated with continuing education for each of these categories of membership varies. Continuing education needs to be undertaken every year either from the Institute of Architects or other recognised relevant professional bodies.
- There are regional chapters in 28 provinces across Indonesia. The central Chapter is in Jakarta. The decisions by the Institute of Architects are undertaken centrally and the chapter enforces the decisions undertaken centrally to the local Chapters.

- There are 50 members on the Board for the Institute of Architects, mostly practicing architects and university members. There is representation from the various chapters on the Board. The Board has specialists in the Committee, such as professional practice, history, etc. There are eight full time staff based in Jakarta. About 200 professionals join the Institute of Architects as professional members, annually.
- The architecture profession is not yet self-regulated. There is no legislation recognising architect as a profession, unlike the engineering profession in Indonesia. The 'ask' is for the Architecture Board to be tripartite comprising academia, industry and government.
- Reviews are undertaken by the chief of education from the Institute on a regular basis, but outcomes cannot be enforced, as the Institute does not have a legal status.
- The Institute of Architects facilitate and provide professional development on green buildings/sustainability to practicing professionals. The audience usually comprises of architecture practitioners and university academics.
- Foreign architects can practice in Indonesia under special permits. There is a concern that foreign architects are flooding the market and taking jobs away from the local architects.
- APTARI (Asosiasi Pendidikan Tinggi Arsitektur Indonesia) is a voluntary body formed by academics. Academics contribute their time to this organisation. It represents various schools of architecture across Indonesia. Subcommittees of APTARI include heritage, housing, technology, and history and theory of architecture. APTARI exists as a membership based organisation where various schools pay a membership fee. APTARI are working with the Institute of Architects to support regulation of the architecture profession.
- Generally, private clients do not understand sustainability and climate change, so there is no demand from them.
- Not all architects are registered. Some architects just focus on design and hire relevant skills to meet the local regulatory requirements.
- If consultants are hired, the architects may or may not follow their recommendations. Skills to recognise design implications of the consultant's recommendations may or may not be acknowledged.
- As there is no central building code, there is no technical guidance provided, leading to disconnect and misunderstanding.
- There are also disconnects between the requirements of the code to what happens in practice. It is not just the case of policing the building code regulations, but also that practitioners are not engaged—they do not believe in the value of adhering to the requirements of the code.
- Feedback to the design, construction and engineering team is not part of the normal process of understanding how buildings are performing from an operational perspective, both in terms of resource use and functionally.
- There is general lack of understanding by architects of the impact of integrating design/design led teams.

- Energy efficiency is seen to be a specialist area and is outsourced in most architectural practices. There is no shared ownership of the outcomes so there is frustration on the part of architects, who claim that creativity is stemmed.
- Industry practitioners usually start people 'young'; they like to train the young staff to their own understanding of the nature of architectural practice.
- Some parts of the industry are moving towards becoming fully electronic such as through the use of Building Information Modelling (BIM), but others are not.

5.2 Educational Concerns

The educational concerns across the academics interviewed were more or less similar. The industry practitioners also provided commentary regarding the education of architects in Indonesia.

- There is disparity currently in the curriculum across the schools of architecture, impacting on the quality/standard of education. The architecture curriculum is not set by a central body, leading to discrepancies, particularly in the regional centres across Indonesia. The Institute of Architects is currently working towards setting up architecture competencies.
- Schools generally have a four year program, with a final year of professional practice exposure to give students the professional knowledge to become an architect. Five year programs are critical to get recognition from the International Union of Architects (UIA). The UIA is a membership based global organisation uniting architects around the world. There are resource implications in running a four year programme vs a five year programme.
- As the country is geographically spread out, regional differences come into play leading to variations in standards.
- There is still a growing relationship between the Institute of Architects and the Schools/Departments of Architecture. Approximately 80 schools/departments of Architecture have signed a Memorandum of Understanding (MoU) with the Institute of Architects.
- There is a qualifications framework for the architecture profession currently being considered, but it is yet to come into effect. This is expected to be rolled out in 2016.
- The Indonesian government undertakes rankings for universities, and these are very broad based rankings. There are national accrediting bodies that accredit the universities. Accreditation is every 5 years, with one year of annual review.
- Usually a school or department of architecture gains prestige through awards providing recognition to the alumni of the universities. Universities tend to get recognition as a result of prestigious awards to the alumni.
- There are disconnects between what academics think needs to be taught versus what industry believes is critical. For example, some academics felt that the schools address sustainability and climate change education, but others felt it

was not enough. Where sustainability and climate change courses may be offered, it is usually offered as an elective.

- Curriculum development is undertaken at the unit/department level. Sustainability and climate change issues may or may not be considered to be relevant to the curriculum. If offered at all, it is offered as an elective and not core programme. Integration of sustainability and climate change in the curriculum are usually not discussed in formal university reviews.
- Universities do not have a formal process of engagement with the public. They tend to use informal processes of engagement with the industry. However, any changes made to the curriculum are formal and need to follow a formal process of approval involving senior management of the university.
- Full time academics may also be practicing architects. This creates a lot of problems with the research outcomes of the universities, as there are split incentives between the practice of architecture and research outcomes.
- There is a big gap in the knowledge areas of some academics; hence they are not able to teach in some contemporary areas such as climate change and sustainability. Capacity building amongst the academic staff is needed.
- The Institute of Architects plays a role in education; they inform educational institutions about changes impacting on the profession.
- A practitioner noted that it takes at least 6 months to train someone to understand building modelling and undertake work under guidance. Therefore, such types of training may need to be either linked to university teaching or as a separate course post university teaching.
- Sustainability and climate change curriculum is not considered to be a priority. Adding more courses to the existing curriculum is a challenge. Integrating sustainability and climate change is a challenge also because of lack of priority and lack of expertise.
- Legalities around building permits and operation of buildings are not taught as part of the curriculum.
- Small business management skills are also not part of the training given to architects in universities.

5.3 Role of Other Built Environment Professionals

All stakeholders spent some time discussing built environment professionals as not all of them had a degree in architecture. All agreed however, that the built environment professionals needed to work collectively as the industry was too fragmented.

- There are disconnects between the professions comprising the built environment professions. There is no sharing of knowledge, information, shared goals and outcomes.

- Building management is not a recognised discipline, and building managers often do not have the skills to manage buildings.
- As the engineering profession is regulated and recognised as a profession, the engineers certify buildings in Indonesia. Hence, the "power" is in the hands of the engineers and the engineers are employed in most government departments.
- Personal relationships do matter. Where there is someone in position of power from a built environment profession, it is easier to engage with the bureaucracy and bring change. For example, a national built environment professional, being a Minister, understands the issues involved, and is prepared to engage in making changes recognising the importance of the built environment.
- There is silo mentality in the built environment. Engagement with the various sectors of the built environment is time consuming. There needs to be a rather long lead time for implementation.
- There is a dearth of shared learning with the built environment sector.
- There are gaps between the industry, university and the market place.

5.4 Regulatory Landscape

The regulatory landscape was also fragmented. Lack of knowledge, technical skills were highlighted, as also the political will to bring regulatory changes and police the changes.

- Typically, in a local government office, there may be 30 or so staff, of which only a third or so may have some sorts of qualifications; usually only a Bachelor degree qualification. A range of built environment professions may be covered; for example, planning or engineering.
- Of the staff working in the local government offices, not all staff are working full time, which also creates classic problems of knowledge retention.
- "Green" is considered to be a symbolism and there is lot of 'green wash' in the industry and market place. The focus is on signature buildings rather than making real change to the built environment.
- Foreign architects can practice in Indonesia under special permits.
- To bring in changes for sustainability and climate change, there needs to be better alignment between local jurisdictions and federal jurisdictions.
- Enforcement of law is through the local jurisdictions, which in turn, requires working in alignment with the national bodies.
- As there are not too many technically qualified people, the focus tends to be on the administrative side of local government. Mayors have a lot of power and they can support various initiatives if they so desire. The current mayors of Jakarta and Bandung are touted as mayors who are making changes to the built environment as they have a background in these professions leading to their ability to influence and lead change in the built environment.

- Where technical assistance for regulatory information is not available, support from further up the chain, often from the provincial level is sought. Most of this piles up due to communication issues and the hierarchical nature of operation during the working year. However, towards the end of the financial year, there is some pressure to get these issues resolved.
- Related government department for building and construction have approximately 6000 employees, of which half are in Jakarta and the others are spread across the country. There are regional offices in the various provincial centres that can communicate with the provinces, but communication itself is not always effective.
- Technical solutions need technical support for resolution. With the dearth in qualified staff, this creates problems. Therefore, technical knowledge in most government department is not up to date.
- There is a close collaboration between the government departments dealing with civil works and the department dealing with housing.
- Regulations for energy and sustainability in buildings have been in place since 2013, and have been applied only in Jakarta with recent moves to introduce it in Bandung. Such regulations have been introduced recently with support from international organisations such as the International Finance Corporation. Currently, regulations are underway in Jakarta and will be followed through to Surabaya and Makassar.
- Leading global civic bodies are involved in ensuring there is awareness and voluntary standards—predominantly green building standards through 'greening the building code of Indonesia'. Investment in green buildings by spreading awareness of green building through the use of some tools has also been driven by global organisations. This 'push' is in the form of using standards, higher than the code with a 20 % improvement on energy of construction materials used in the building. Five types of buildings are currently covered under this: homes, hospitals, hotels, retail and office buildings. More time is needed for these standards to become the mainstream.
- The process of construction itself in Indonesia is not straightforward. It takes a long time to get permits for construction. If sustainability and climate change concerns are overlaid onto this, it will become an additional burden for all stakeholders. Hence, a considered decision as to how sustainability and climate change may be applied in practice in Indonesia needs to be debated.
- Where changes need to be made in practice, consultants rather than university staff are engaged. This is because the specialised area may be beyond the scope of expertise of university staff. Usually university staff may be engaged in heritage preservation, but usually not in green building/sustainability and climate change considerations.
- Private sector engagement is critical for mass transformation towards green buildings and the government is reluctant to upset the private sector. It is critical to seek private sector engagement in bringing changes for improvement in the built environment in Indonesia.

It is clear that there are several issues impacting on green building outcomes in Indonesia. From the perspective of the architecture profession, lack of self regulation is impacting on the ability to maintain standards and quality of the profession. Without the ability of this professional recognition, the power to have a 'voice' in the future of built environment in Indonesia is stymied. The ability to influence the curriculum in the architecture schools in Indonesia is also impacted. While there is some input currently into the curriculum, the geographical spread of the country makes it difficult to maintain quality and standardisation of the curriculum with the current situation. Any changes to consider building sustainability or climate change needs to be supported by the accreditation of the programmes of architecture, thereby, architecture as a profession needs to be recognised as the first order of priority.

Changes to the building code are also important, however, these changes impact all the related built environment professions responsible for designing, constructing and operating buildings: facility managers, project managers, asset managers, architects, construction managers and engineers. The current obvious disconnects between the various disciplines needs to be bridged, and it is not surprising that this is happening in Indonesia. Other countries such as the USA and Australia have also traversed a similar journey at the early stages of implementation of industry best practice and green building code. To gain traction and recognition in the market place, in countries such as Australia, there was commitment to green building outcomes by local councils and governments along with support from some visionary private companies (Iyer-Raniga and Moore 2008).

Building code developments are minimum standards and the industry needs to be committed to move beyond minimum standards to the development of best practice standards. The development of green building councils in other countries such as Australia demonstrates that industry need to be convinced of the importance of green building to invest in such types of buildings. This investment is a result of a combination of "doing the right thing" and demand from the consumers. Indonesia has yet to be convinced of the need to focus on green buildings from an ethical/moral perspective and scope for demand from within the country has yet to be developed. A question arises therefore, that if green building development is to be fast tracked, one clear approach is through curriculum development so that the next generation of built environment professionals have the know-how to deal with the challenges of climate change and sustainability.

Curriculum development for green building requires examples and case studies of green building practice as theoretical knowledge alone is insufficient. Therefore, university academics, government and industry need to bridge current gaps to share knowledge and information. Such knowledge needs to be developed and disseminated as professional development for industry and academics. Furthermore, a repository of resources within the country needs to be developed that are contextualised for the culture and climate of Indonesia.

Lack of studies on post occupancy evaluation, drawing attention to issues such as productivity and health/well being of occupants and savings in cost need to be provided. Such examples of success in green buildings in the region are available, such as in Singapore [similar to Indonesia in climate are available, see for example Kishnani et al. (2014)]. A repository of knowledge such as this would support green building development in Indonesia. Lack of feedback post occupancy currently does not assist the architecture profession holistically in spreading evidence based design. It also does not assist the facility management profession to understand the impact of designs and support in optimising building operations.

Development of an educational curriculum that supports green building and sustainability is possible only when a clear need for this arises. Currently, there are no drivers through either the accreditation of the architecture programmes or through regulatory changes in the building code. As a number of academics are also practicing architects, the focus is on the design and aesthetics of the profession and not on the 'green' outcomes of the architecture profession. Furthermore, there is a dearth of professionals with this knowledge, not just in architecture but also across the suite of built environment professionals. The same issues arise in the building related departments of the various jurisdictions because existing staff are either not qualified or lack the available technical knowledge.

6 Future Outlook

In the short term, Indonesian government, regulatory, professional and university stakeholders all need to work collectively to align with the demands of climate change and sustainability. There are changes in the landscape that need to be considered so as to align with the collective climate change and sustainability targets globally. The architecture profession is facing increased competition from ASEAN (Association of South East Asian Nations) countries/architects. Other ASEAN countries have regulated the architecture profession already, and the Indonesian architects are at a disadvantage.

Working with organisations such as Building in Indonesia Sustainability Alliance (BISA) is helpful in ensuring a facilitated support for education and awareness for sustainability in Indonesia. It is not uncommon for students in Indonesia to receive qualifications from overseas in both undergraduate and postgraduate degrees. This is expected to continue in the future. As salaries are not competitive, it is not unusual for young architects to either remain overseas (particularly if they have studied overseas) or go overseas to neighbouring countries such as Singapore so that they are economically well off. When graduates who are exposed to green thinking and practice end up working in other countries the capacity to influence the built environment professionals in Indonesia are limited. Therefore, support for recognising the architecture profession is critical.

There needs to be better engagement and collaboration between the market, current building industry practitioners and universities. For government organisations in particular, the image of green buildings is important as they are under international pressure to lead green initiatives. They need to lead the green building movement by setting examples for their own tenancies. Similar to other countries such as Singapore and Australia, Indonesian government needs to drive the green building movement through leading by example, so that the private sector is convinced to follow. While setting up the green building code is a good starting position, regulations are about minimum standards to bring the industry to a common platform. There needs to clear drivers to push the envelope for innovation and best practice in the green building movement in Indonesia by the private sector.

7 Conclusions

This chapter commenced with a literature review of the state of sustainability education. A focus on Indonesia as a developing country demonstrates that the future of the built environment is in troubled waters if changes to the way the built environment professions are trained and interact with each other are not undertaken urgently.

Using the architecture profession from amongst a range of built environment professions as a spotlight, a case has been presented that to embed lasting and holistic changes to architectural education, there needs to be a critical understanding of not just professional development needs for educators and industry practitioners, but also an awareness and understanding of institutional frameworks and networks that shape the profession. Such an approach provides a critical insight in shaping the profession, so key drivers may be identified that maximize outcomes for the built environment.

Interviews with a range of building industry and academic stakeholders were undertaken. From an architecture industry perspective, self regulation is the greatest priority. Lack of a central building code has lead to fragmentation. There is no alignment between the building code (where it exists) and the practice of architecture. There are no shared goals for building design and construction, as a result, green building is not considered to be part of the mainstream design and construction. From an educational perspective, there is no uniformity in the structure or in the curriculum of the schools of architecture. Neither is there any uniformity in what the academics consider as being core subject/s for the architecture programmes. Climate change and sustainability is not taught in the schools of architecture, and where it is, it is considered as an elective.

Extending from the architecture to the other built environment professions shows no collective goal for the stakeholders in the building industry. Each profession works in silos, leading to gaps in the industry, university and the market place. The regulatory landscape for the building industry also has disconnects, with a piecemeal approach to application in some jurisdictions and not uniform application across the country. Lack of technically qualified personnel at the various jurisdictional levels leads to administrative rather than technical focus, which is not desirable. Private sector generally lags behind government initiatives.

Therefore, a systematic and collaborative approach is required where just focusing on improving the capacity of built environment professionals through training and professional development alone is not sufficient. The linkages and connections between a built environment discipline, industry, government and related institutional players, and with other built environment disciplines need to be developed and closely monitored for ongoing feedback and improvement. In charting their own directions towards a low carbon future, developing countries need to advance a multi-dimensional awareness and methodology, contemplating a broader institutional approach for the built environment disciplines.

References

Baumert, K. A., Herzog, T., & Pershing, J. (2005). *Navigating the numbers greenhouse gas data and international climate policy*. USA: World Resources Institute.

Connor, R. D., & Dovers, S. R. (2002). *Institutional change and learning for sustainable development* (Working Paper 2002/1). Canberra: Centre for Resource and Environmental Studies, Australian National University.

CSIRO & Bureau of Meteorology. (2015). In Whetton, P., Marie Ekström, C. G., Grose, M., Bhend, J., & Risbey, L. W. A. J. (Eds.), *Climate change in Australia projections for Australia's natural resource management regions*: *A technical report*. Australia: CSIRO and Bureau of Meteorology.

Fitch, E., & Laquidara-Carr, D. (2013). *World green building trends business benefits driving new and retrofit market opportunities in over 60 countries*. Bedford, MA: SmartMarket Report.

Hallegate, S., Heal, G., Fay, M., & Treguer, D. (2011). From growth to green growth a framework. *Policy research working paper 5872*. The World Bank.

Hoornweg, D., & Freire, M. (2013). Building sustainability in an urbanising world. *Urban development series*. Washington: Urban Development & Resilience Unit, World Bank.

Iyer-Raniga, U., & Andamon, M. (2012). Sustainability education in the engineering and built environment curriculum: The case for Asia-Pacific. In *5th international conference of education, research and innovation* (*iCERI*). November 19–21, 2012. Madrid, Spain.

Iyer-Raniga, U., & Andamon, M. (2014). Embedding sustainability education in a built environment curriculum. In A. Tanaka & M. Tabucanon (Eds.), *Transforming higher education and creating sustainable societies*. Tokyo: United Nations University—Institute for Advanced Study of Sustainability.

Iyer-Raniga, U., & Andamon, M. (2016). Transformative learning: Innovating sustainability education in built environment. *International Journal of Sustainability in Higher Education, 17*, 105–122.

Iyer-Raniga, U., & Moore, T. (2008). Reducing environmental footprint: Mornington Peninsula shire council case study. In *Sustainable buildings conference SB08*. September 21–25, 2008, Melbourne.

Keohane, R. O., & Victor, D. G. (2011). The Regime Complex for Climate Change. *Perspectives on Politics, 9*, 7–23.

Kishnani, N., Tan, B. K., Bozovic Stamenovic, R., Prasad, D., & Faizal, F. (2014). Post-occupancy evaluation of green mark-rated buildings in Singapore. In *World sustainable buildings 2014, sustainable building*: *Results are we moving as quickly as we should*? *Its up to us*! October 28–30, 2014, Barcelona Green Building Council Espana.

Lozano García, F. J., Kevany, K., & Huisingh, D. (2006). Sustainability in higher education: What is happening? *Journal of Cleaner Production, 14*, 757–760.

Nomura, K., & Abe, O. (2011). *Sustainability and higher education in Asia and the Pacific* [Online]. Global University Network for Innovation. Available: http://www.guninetwork.org/

resources/he-articles/sustainability-and-higher-education-in-asia-and-the-pacific. Accessed July 30, 2012.
North, D. C. (1990). *Institutions, institutional change, and economic performance*. Cambridge: Cambridge University Press.
North, D. C. (1994). Economic performance through time. *The American Economic Review, 84*, 359–368.
Scott, W., & Gough, S. (2006). Sustainable development within UK higher education: Revealing tendencies and tensions. *Journal of Geography in Higher Education, 30*, 293–305.
Snow, M., & Prasad, D. (2011). Climate change adaptation for building designers: An introduction. Available: http://environmentdesignguide.com.au/media/EDG_66_MSa.pdf. Accessed February 06, 2012.
Sterling, S. (2004). An analysis of the development of sustainability education internationally: Evolution, interpretation and transformative potential. In J. Blewitt, & C. Cullingford (Eds.), *The sustainability curriculum: The challenge for higher education* London: Earthscan Publications.
Sterling, S., & Thomas, I. (2006). Education for sustainability: The role of capabilities in guiding university curricula. *International Journal of Innovation and Sustainable Development, 1*, 349–370.
Stevenson, R. B., Brody, M., Dillion, J., & Wals, A. E. J. (Eds.) (2013). *International handbook of research on environmental education*, New York, NY/Oxon, UK: Routledge for the American Educational Research Association (AERA).
Thomas, I. (2004). Sustainability in tertiary curricula: What is stopping it happening? *International Journal of Sustainability in Higher Education, 5*, 33–47.
Tilbury, D. (2011). Sustainability in higher education: A global overview of progress and possibilities. In Global University Network for Innovation (GUNI) (Ed.), *Higher education in the world 4: Higher education's commitment to sustainability: From understanding to action.* Palgrave Macmillan.
Torcellini, P., Pless, S., Deru, M., & Crawley, D. (2006). *Zero energy buildings: A critical look at the definition*. Oakridge, TN: National Renewable Energy Laboratory (Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy).
UNEP. (2009). *Buildings and climate change: A summary for decision-makers*. Paris, France: United Nations Environment Programme (UNEP).
UNEP-SBCI. (2012). *Sustainable building policies in developing countries* (*SPoD*). Paris, France: United Nations Environmental Program—Sustainable Building and Climate Initiative (UNEP-SBCI).
World Bank. (2012). *Putting higher education to work: Skills and research for growth in East Asia* (*The World Bank East Asia and Pacific Regional Report*). Washington, DC: The International Bank for Reconstruction and Development, The World Bank.
Yarime, M., Trencher, G., Mino, T., Scholz, R. W., Olsson, L., Ness, B., et al. (2012). Establishing sustainability science in higher education institutions: Towards an integration of academic development, institutionalization, and stakeholder collaborations. *Sustainability Science, 7*, 101–113.

The Sustainability Journey of USM: Solution Oriented Campus Ecosphere for Vitalising Higher Education Action on GAP

Omar Osman, Kamarulazizi Ibrahim, Kanayathu Koshy, Noor Adelyna Mohammed Akib and Ahmad Firdaus Ahmad Shabudin

Abstract

Grappling with the challenges of sustainable development will require a total change in the way we interact with the ecosystems that support our lives and the people we live with. This means that all individuals and societies must be equipped with knowledge, skills, perspectives, values and issues that enable them to drive such changes. Consequently, universities across the world have been trying to integrate Education for Sustainable Development (ESD) into their curriculum. This global ESD commitment gained further strength when the UNESCO World Conference on ESD launched the Global Action Programme (GAP) on ESD in 2015 with five priority areas. The sustainability journey of Universiti Sains Malaysia (USM) has a lot in common with the experience of UNESCO globally and GAP in particular, in that the University too is convinced, with its long-term involvement in ESD, that a *whole-institution* (*GAP Priority 2*) commitment which involves *policies* (*GAP Priority 1*) and practices which factor the creativity of *educators* (*GAP Priority 3*), and the youthful vigour of *students* (*GAP Priority 4*)

O. Osman (✉)
Universiti Sains Malaysia, Penang, Malaysia
e-mail: omar_o@usm.my

K. Ibrahim · K. Koshy · N.A.M. Akib · A.F.A. Shabudin
Centre for Global Sustainability Studies, Universiti Sains Malaysia, Penang, Malaysia
e-mail: kamarul@usm.my

K. Koshy
e-mail: kanayathu.koshy@gmail.com

N.A.M. Akib
e-mail: adelyna@usm.my

A.F.A. Shabudin
e-mail: as_firdaus@usm.my

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_23

are integral to promoting relevant changes that befits the needs of all *stakeholders* (*GAP Priority 5*) today and tomorrow. These examples that enable the campus ecosphere to align itself to the broader priorities of sustainable development and vitalise the university across the board to promote learner centred and solution focused education. The intention of this paper is to share USM's sustainability experience with a wider group of practitioners in the hope that it will enhance action toward GAP and a bigger process of institutional learning for sustainability.

Keywords
Education for sustainable development (ESD) · Higher education institution · Institutional development · University communities

1 Introduction

The global ESD commitment gained further strength when the UNESCO World Conference on ESD launched the Global Action Program (GAP) on ESD in 2015 at Nagoya, Japan with the overarching goal is 'to generate and scale up action in all levels and areas of education and learning to accelerate progress towards sustainable development' and five priority action areas. Notably, the move to expand ESD into higher education under a Global Action Plan starting in 2015 was marked in the Nagoya Declaration on Higher Education for Sustainable Development unveiled on 9 November in Japan. Higher Education Institutions now has the responsibility and commitment, more than ever before, to strengthen and support SD agenda that explicitly linking the 17 Sustainable Development Goals and GAP into all their actives in teaching, research, community engagement and campus operational and management.

With a story line involving selected activities across the Universiti Sains Malaysia, especially following the beginning of the new millennium, we try to demonstrate how closely some of our efforts have been aligned to the five priority areas of the post 2015 ESD agenda, GAP. Although there is this broad coherence, we are fully aware that when it comes to details there are gaps that need to be bridged and innovative programs introduced in each of the areas GAP has identified for accelerated ESD action.

2 Background

Universiti Sains Malaysia (USM) was accorded the prestigious Accelerated Programme for Excellence (APEX) status in 2008 under auspices of the Malaysian Ministry of Higher Education with aspires to be a world class sustainability-led university and utilises higher education as a platform to mainstream sustainability into all level of societal. Since APEX Phase I (2008–2013), USM has made multiple efforts to transform its campus ecosphere towards sustainability through teaching, research and community engagement initiatives and campus operational.

Moving on from the Decade of Education for Sustainable Development and embracing GAP on ESD in 2015 and its five priority areas: (1) policy support; (2) whole-institution approaches; (3) Educators; (4) Youth an (5) local communities, USM has strengthened its commitment to the principles and practices of ESD. This paper highlights five such specific initiatives of USM under: (i) USM Policy on Sustainable Tomorrow, (ii) The APEX sustainability initiative, (iii) Staff participation, (iv) Student programs and (v) USM-stakeholder engagement, which are aligned to the GAP priorities. The rationale behind this approach is our conviction that in every sustainability conscious university it will be possible to identify a set of programs and activities that could be linked to the priority areas of GAP. Having had a sort of 'head start', such institutions could identify a host of early action to promote the more specific recommendations of GAP and eventually through gap filling and replication of best practices from across the world, it will be well within the capacity of proactive universities to support global efforts to graduate a set of sustainability leaders. It is in their hands and under their watch sustainability will become a smart way of life that enables tomorrow to be better than today.

The authors of this paper and CGSS/USM have been engaged in a number of 'process' research that critically analyse the way we have come this far in our sustainability journey, evaluate current standing in relation to regional and global ESD priorities, and project possible trajectories for the promotion of sustainability within higher educational institutions. This approach has taught us that we need to be dynamic to capture each opportunity that our teaching and research provides, network both internally and externally to be in the midst of like-minded academics to mould sustainability infused graduates and be courageous as an institution to be guided by innovative policies and praxis to commit human and financial resources to produce the results we seek. It is hoped that the following sections will provide adequate coverage for what we intent to covey.

(i) USM Policy on Sustainability

Over the years, USM has made strong commitments to internal and international efforts to prevent further irreversible environmental change and sustainable development in its policy and this is in line with the first priority area of GAP i.e. policy support. Recognising that the current global growth paradigm continues to make it harder to set human development on a sustainable trajectory, the university reaffirms the urgent need for its graduates to be fully literate in the knowledge to chart a sustainable future for them. Aligned with the global thinking, i.e. WSSD 2002 and Rio+20 2012, USM has selected water, energy, health, agriculture and biodiversity (WEHAB) as the five major priority sectors, and climate change/disaster risk management, production/consumption and population/poverty as the three cross sectoral areas that form the major sustainability priorities for focused intervention, collectively called 'WEHAB+3' (Universiti Sains Malaysia 2014).

The principal approach of 'WEHAB+3' are to, (i) Adopt sustainable development as a major guiding principle in the overall operations, including teaching, research, community engagements and institutional arrangements, (ii) Educate USM students with the right blend of knowledge and interdisciplinary skills, suitable for adaptive management, critical reflection and participatory approaches needed for sustainability, (iii) Ensure that research performed addresses environmental, social and economic problems and that efforts are made to translate research findings into policy and public knowledge, (iv) Create an appropriate institutional culture by 'walking the talk' through campus sustainability efforts, (v) Establish alliance and partnership with relevant stakeholders in the public and private sectors to promote sustainable development, and (vi) Nurture and educate young people to be leaders and agents of change for a sustainable future.

With such a focus on WEHAB+3, the 'USM Policy on Sustainability (2014)' and its implementation ideas such as 'What can USM do to Fast-track Sustainability', 'USM Five-year Plan' and 'Sustainability Capacity building' across USM in four major domains—teaching, research, community engagement and institutional arrangement, USM endeavours to integrate sustainability into all its mission areas. Progress in this process is periodically monitored using the computerised 'Sustainability Assessment Methodology' (SAM) (Sibly et al. 2014). SAM nested within the sustainability integration model of USM, was developed by the CGSS using 24 key sustainability criteria aligned to the content of the internationally agreed documentation such as, Stockholm Declaration—UN Conference on Human Environment, Brundtland Commission Report, Agenda 21 (UN Conference on Environment and Development—Earth Summit), Earth Charter, Johannesburg Plan of Implementation (UN, World Summit on Sustainable Development), The Future We Want (UN Conference on Sustainable Development—Rio+20) and other relevant national reports from government and civil society reports on sustainability.

(ii) The APEX sustainability

Transforming learning and training environments through the integration of holistic sustainability principles as a key of USM institutional development. USM agendas since the new millennium, such as Kampus Sejahtera (Campus well-being) 2000; USM as a Regional Centre of Expertise in ESD 2005; University the Garden concept in 2006 and APEX status in 2008, provide a special focus on sustainability education (Universiti Sains Malaysia 2008; Univesiti Sains Malaysia 2013a). The Sejahtera concept has been developed and practiced by the University Sains Malaysia and RCE Penang since 2000 and it is the conceptual framework used to embed sustainability at the university and engage its community in learning for sustainability. Meanwhile, the University the Garden concept epitomises the basic foundation of life and being—that of the intrinsic relationships between Man, his Creator and Nature.

A sustainable world, humanity and the future of the humankind are among the issues focused on by USM. Based on these over-arching principles, USM has been chosen by the Malaysian Ministry of Higher Education to implement the Accelerated Programme for Excellence (APEX) under its auspices in 2008. Convinced that building capacity for making decisions that consider the long-term future of economy, ecology, and equity is a key task of education, USM has embraced the vision of becoming a sustainability-led university of world-class standing as part of its APEX initiative.

As the first APEX university, USM adopts a two-tiered approach. First the university aspires to be world renowned for sustainability concept. Second, it also aims to be a sustainability-led university (Universiti Sains Malaysia 2008). APEX serve as a platform for USM to transform learning and training environments concerns not only managing physical facilities more sustainably, but also changing the ethos and governance structure of the whole institution. During APEX first phase USM laid the foundation for the later phase by adopting five critical agendas as its guiding. These are: (i) transforming higher education for a sustainable tomorrow, (ii) creating cutting edge, high value innovative flagships, (iii) reaching out towards the bottom billion, (iv) translating sustainability into action via the Sejahtera concept, and the university in the garden concept and (v) leveraging on scenario planning 'the blue ocean strategy'.

While the APEX award is a fitting recognition for the university's wide–ranging and remarkable accomplishments of the past, it is also a call to excel in addressing the sustainability challenges of the future. In order to achieve the broad APEX vision, USM has embarked on a range of missions which through their specific objectives and activities are expected to contribute to the achievement of the overall sustainability vision. USM APEX university's sustainability strategy, framework and action plan are contained in two important documents: (i) Transforming Higher Education for a Sustainable Tomorrow elaborates the transformations that needs to occur within USM with regard to sustainability integration and reformation, and (ii) the USM-APEX Sustainability Roadmap describes how these changes are to be implemented within the university and identifies the players and their respective responsibilities in achieving USM's sustainability agenda.

The following are some of the achievements of APEX I highlighted in USM's APEX journey (2009–2013) (Universiti Sains Malaysia 2011),

i. Turning waste into gold: halal collagen—USM has successfully produced food-grade halal collagen from ovine skin. Ovine skin or sheep skin is considered a bulk waste in Australia and was historically buried or discharged in a manner that would not cause environmental or biological hazard.
ii. Halal Meningococcal Vaccine: Recognising the predicament faced by Muslims around the world, USM has been focusing on building a solid platform for a halal hub.
iii. Mobile Teleradiology: Establishing high-tech medical solutions in low-tech environments with the invention of Mobile Extensible Medical Image Analysis and Visualisation Platform (ENDEAVOR-Mobile). The ENDEAVOR-Mobile

enables doctors to immediately crowd source expert opinions on critical medical cases from their colleagues, regardless of time and location. It deploys advanced medical imaging technologies developed in USM over several years.

iv. The Rubber Genome Project: Given the varied uses of rubber from medicine to transportation and to address the increasing demand for natural rubber globally, research in USM has decoded the first ever draft of the approximately two-billion base genome of the rubber tree using its seamless genome-base discovery platform.

v. Deciphering ancient architecture: The Sungai Batu Archaeological complex (the oldest sites of civilisation in Southeast Asia) is located at the banks of Sungai Batu, one of the confluences of the Merbok-Muda riverine network.

vi. Malay Braille for the sighted: eKodBraille is the first online multimedia tutorial system with an embedded Braille simulator to teach Malay Braille sighted individuals via the internet.

Based on the considerable achievements of USM in laying a strong sustainability foundation during Phase I (2008–2014) of the APEX program, using Blue Ocean Strategy, to transform governance, enhance efficiency of human and financial resource management, improve infrastructure, boost research and innovation output, and advances in academic reformations, USM entered an ecosphere of APEX Phase II (2014–2025) (Universiti Sains Malaysia 2010). In the ecosphere of APEX Phase II, USM aims to produce talents with a global citizen mindset based on the best values, while the enabler will be the core in APEX Phase II (see Fig. 1), which includes governance, financial sustainability, research and innovation, global citizenry, academic transformation, services, and positioning agenda. Phase II will move towards the direction of prominence, eminence, relevance and dominance in all things that we planned for without neglecting the seven thrusts of APEX—The Future, Uniqueness, Sustainability, Humanity, University, Change and Sacrifice (Universiti Sains Malaysia 2013b).

In APEX Phase II, the continuation effort and improvement on APEX Phase I have been formulated in order to become a university that championed in the sustainability issue or to be recognised as a Sustainability-led University. In pursuing the path of sustainability as the way forward under APEX Phase II ecosphere, USM embraces the protection of multiple ecosystems, the conservation and restoration of sources, as well as heightening human and intellectual capital and consequently, improve the human well-being especially the world's bottom billion. Thus, transforming learning and training environments through the integration of holistic sustainability principles into teaching and learning process, research and innovation activities, community engagement projects, campus operational and management become a core strategy for USM-ESD implementation.

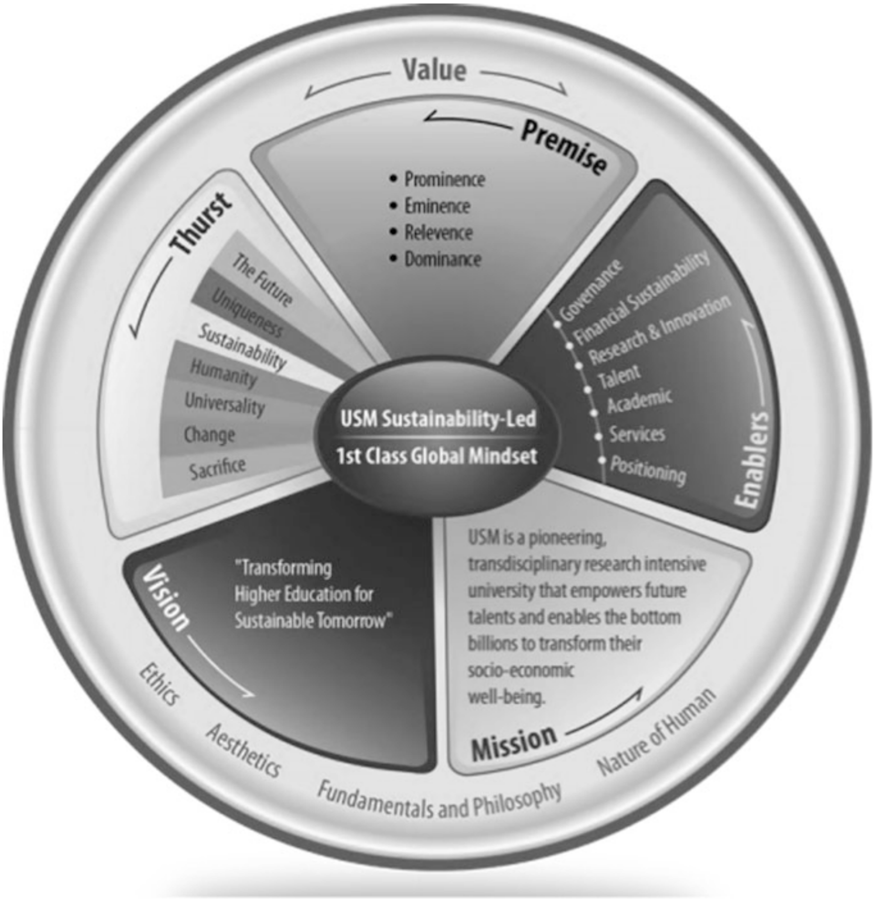


Fig. 1 Ecosphere APEX phase II

(iii) Staff Participation

In the university context, staff (academic and administrative) are key agents of change for delivering educational responses to sustainable development. In order to promote sustainability and to highlight the need for comprehensive awareness and capacity building, the university needs to integrate ESD into every Responsibility Centre (PTJ), with the aims of improving the PTJ's ability to educate sustainability issues, to conduct and supervise sustainability related research and to organize community engagement. Another useful action area of the university is introducing sustainability lens into professional development programs or activities for academic and administrative staff.

Since employees spend a large portion of their lives at work each day, and creating a culture of employees that value their surroundings and sustainability are vital for sustainability promotion, USM has a special focus on providing adequate space for relaxation, exercise and catering outlets. USM has also organised a series of workshops on sustainability implementation at the workplace for non-academic (management/professional and administration/support) and academic staffs to provide general guidelines for sustainable environmental practices and promote healthy lifestyles.

To address sustainable development issues among university students, academic staff must acquire the necessary knowledge, skills and values on global and national sustainable agenda and develop the requisite motivation and commitment towards a sustainable society. In fact, academician and researchers play a vital role in making professionals in these areas aware of sustainability issues, and ultimately in guiding their decision making processes to support sustainable development. Thus, a 'Sustainability Integration in USM Curriculum Laboratory' was organized in three USM campuses, Main Campus (Penang), Engineering Campus (Penang) and Health Campus (Kelantan), to integrate ESD elements in teaching, research and community engagement. The program provides a platform for academic staff to discuss and develop ideas on sustainability integration strategy and praxis in the university education system (formal, non-formal and informal). The Post Rio+20 International Conference 2013 was another initiative organized by USM in view of the increasing importance of sustainable development, green economy and SDGs.

As a way forward in the promotion of institutional sustainability the Centre for Innovation and Productivity in Public Administration (PIPPA) was established by USM in 2012. This research-based training centre offers opportunities for lifelong learning for public sector employees in Malaysia and other developing countries. PIPPA plays an important role in translating training into more practical activities to foster innovation, productivity and sustainable culture among USM academic and non academic staff.

(iv) Student Program

In line with this year's 3rd World Symposium on Sustainable Development at Universities (WSSD-U-2016) theme "Designing Tomorrow's Campus: Resiliency, Vulnerability, and Adaptation", USM aims to support the drive to improve the well-being of humanity, the bottom billion in particular, by educating the students (undergraduate and postgraduate) in ESD. This will generates awareness and understanding among future generation that education is the key to change unsustainable lifestyles and mindsets.

Universities with a large cohort of youths are the prime places for catalyzing change to optimize the development of ESD. With this realization, USM envisioned a number of initiatives with regard to formal curriculum development. For example, the elective course on sustainability, WSU 101 (Sustainability: Issues, Challenges and Prospects) for undergraduate students, offered by CGSS, emphasizes hands-on sustainability challenges in a learning by doing mode. At the end of the course, students develop a comprehensive project report which forms part of the continuous assessment for the course. At the postgraduate level, USM has introduced several masters programs: Sustainable Cities and Communities, Community Medicine-Environmental Health, Sustainable Development Science and Environmental Journalism, Environmental Science, Sustainable River Management, Environmental Engineering and Sustainable Tourism Development. CGSS offers three postgraduate degrees by research; Master of Science (Sustainability), Master of Arts (Sustainability) and Doctor of Philosophy (Sustainability), and also one postgraduate degree by coursework; Master's in Sustainable Development Practice (MSDP). The MSDP is an interdisciplinary program that consists of two years of coursework in four intersecting disciplines such as health science, social science, humanities and management science. There is also a cross sectorial training or internship component, which will require the students to work with communities, industries and government agencies to provide practical solutions and recommendations for addressing the complex development challenges of the stakeholders.

Pimpin Siswa is a leadership program developed by USM since 2009 to provide first year students with experiential training on sustainable living and to develop mostly soft skills. As part of APEX Phase II, a new training module, 'Pimpin Siswa Lestari' (PSL), was introduced in 2015 to ensure that the program outcome aligns with sustainable culture and lifestyle among the students. The module will be mandatory for all first year students as a platform for engaging in issues and innovative solutions for sustainable development. Besides, the implementation of PSL was seen by different departments in USM as a systematic way to introduce students to pursue sustainability goals. Students will be exposed to diverse sources of sustainability components, skills, knowledge and information through PSL which is expected to confer individuals with competency, global mentality and a more competitive & holistic approach to life. Apart from the three traditional triple bottom approach of sustainability, the fourth components Qalbu (in English literally translated to 'soul') and other generic components of PSL are unique elements which synchronize with certain noble values and characteristics of campus life.

Sekretariat Kampus Sejahtera (Campus Well-being Secretariat) (SKS) is another platforms to instill volunteerism in students and support sustainability related activities on campus. Headed by relatively young enthusiasts at the Vice Chancellors office, SKS is now the major vehicle through which all campus sustainability activities are carried out.. There are six clusters of SKS, namely energy efficiency, water conservation, biodiversity, healthy lifestyles, urban agriculture and waste management. The secretariat will give guidance to the USM student community for their commitment and responsibility toward campus sustainability through self-initiatives, proactive teamwork and volunteerism. In addition, the creation of the Students' Consultative Council of Universiti Sains Malaysia (DPP USM) has led to the establishment of the Youth Parliament, which happened to be the first Malaysia Students' Parliament. The Student's Parliament is one of the best platforms available for students to debate and give their insights on national policies and development issues. It also provides for the enculturation of intellectual debate that will enable the student representatives to hone their skills in conveying ideas objectively, based on facts and evidence (Osman 2010).

The 'White Coffin' (Styrofoam food containers) and 'Say No to Plastic' are two hugely successful on-going student-led campaigns which have spread to other universities resulting in a follow-up activity called Tapau-mania. This program encourages the campus community to bring its own reusable containers to pack food from cafeterias and it also has influenced the Penang state government to implement a 'No Plastic Bag' policy since January 2011. Arizona State University (2009) stated since the launch of the White Coffin campaign in 2007, eight universities have emulated this plan in Malaysia and the Penang state government has also initiated USM's green campaign to eliminate polystyrene foam containers use and to reduce the use of plastic bags in government offices. Even the Consumers Association of Penang (CAP) has cited USM in order to publicly pressure large events such as the Indian festival of Taipusam to go green. Every year, these events generate almost a million pieces of polystyrene foam waste over three days. As a result, the organizers of these events have committed to switch at least 10 percent of the disposable containers to biodegradable alternatives and have "zero waste" as their long-term goal (Arizona State University 2009).

Volunteerism is an important element in nurturing the holistic development of university students. The new sustainable development goals are firming up, the United Nations Volunteers (UNV) program and its partner organizations are actively engaging to shape the role of volunteers and volunteerism in the global effort to create a better world (Dictus 2015). USM Volunteer Corps is the result of a combination of 17 different entities. It is a secretariat responsible for ensuring USM governs and manages disaster related issues. An entity known as 'Briged Bencana' (Disaster Brigade) that tackles current issues of disaster within the secretariat. Currently, the Volunteer Corps membership is close to 1500 students. The Corps, based at the IM4U Outreach Center Office, is directly operated and supervised by the Student Affairs and Development Division and the USM Alumni. A total of 165 volunteer-based programs were successfully implemented by the Volunteer Corps secretariats with participation of 5000 students.

(v) Stakeholder Engagement

For more than a decade, one of the key thrusts in promoting sustainability has been working closely with local and global community through various knowledge transfer programs. USM has a broad view of 'Community', which includes village community, industry, business, NGO/NSA, policy and other similar stakeholders. USM's engagement with these groups is always a "knowledge transfer engagement" to address some pressing development challenges of the stakeholders. The community has a lot of experiential knowledge, developed over a period of time and such knowledge is time-tested and will withstand the pressures of the 'red ocean' world. USM realizes that the sustainability challenges are new and emerging and these communities have little experience yet and, by extension have little knowledge and capacity to face up to them. This is where USM features to responsibly engage with them through knowledge pursuits to help find solutions to their livelihood, business, productivity and governance challenges. In all of these, USM thinks broad and acts local. The examples below will help illustrate how USM is pursuing its mandate to work with community, industry and policy makers.

Under the leadership of the Deputy Vice-Chancellor of Industry and Community Network Division (BJIM), there is a number of industry and community focused partnership projects conducted by students and staffs. One of the popular approaches of BJIM for project implementation is called 'clusters'. While the Disabled People cluster addresses the issues of people with disabilities, the Small and Medium Enterprises (SMEs) cluster focuses on up-skilling SMEs46. The 3C cluster (Corporate Conscience Circle), consisting of a team of multidisciplinary staffs and students working to promote enhanced CSR (corporate social responsibility) and USR (university social responsibility). The University Community Engagement (UCE) Cluster facilitates collaboration between USM staffs, students, as well as alumni for meaningful university community engagements.

USM Innovative Community Engagement refers to organizations and individuals engaging in a process of fostering collaboration which benefits the community. The APEX has promoted initiatives that enhance skills and ability of marginalized and disadvantaged groups. The initiatives include 50 community engagement projects, UCEC 2015, University Community Transformation Centre (UCTC) @ USM, Innovations for Community (INNO4C) and Volunteerism in the Community Engagement (CE). USM-Industry collaboration has engaged direct involvement of around 3000 academicians in various university-industry collaboration projects between 2012 and 2015, largely through the private sector, government agencies, multinational corporations, GLCs, NGOs and likewise.

USM leads and advances its global networks via the Asia-Pacific University-Community Engagement Network (APUCEN), South East Asia Sustainability Network (SEASN), Global Higher Education Network (GHEN), Regional Peace Education for Sustainable Development Network (percent) and Asian Local Knowledge Network (NS). These networks provide a platform for exchange information and experience throughout the worldwide to develop new ideas in sustainable development. These networks provided opportunities to foster collaboration among members in research, publication, student exchange programme and capacity building programme.

The Ministry of Higher Education in 2010 initiated the 'Knowledge Transfer Programme' (KTP), another major initiative with a 'community and industry' focus with the objective of recognising and promoting knowledge transfer via the exchange of creative and innovative ideas, research findings, experiences and skills between public HEIs, research organizations, industries, government agencies and the wider community. USM was selected as the national secretariat for this programme. Five Key Results Areas (KRAs) of the KTP that will spur industry growth, community development and improve quality of life as a whole have been identified. They are (a) Education—raising the level of education in certain areas, (b) Economy—economic gain in identifying sectors, (c) Sustainability and Green Technology Initiatives, (d) The Disadvantaged, and (e) Developing Industry/Community Relevant Curriculum (for High Impact Sectors) (Osman et al. 2014). Osman et al. (2016) highlighted that since its inception, 349 projects (industry 219 and community 130) have been implemented throughout the country, with the participation of more than 1400 academic staff, 650 GIs, and 3500 employees from Industry and Community.

In the context of disaster management, sustainability and community engagement, the Centre for Global Sustainability Studies CGSS) actively organising a series of capacity building programmes based on Disaster Risk Management-Sustainable Development (DRM) model developed by CGSS as follows; (a) Training for capacity building—'Disaster Risk Management for Sustainable Development Capacity Building—Malaysia, Vietnam, Lao PDR and Cambodia'. The project is fully funded and supported by the Asia Pacific Network for Global Change Research (APN). A three-day 'learning labs' (for each country) has involved about 60 participants in Malaysia and 30 participants in Vietnam, Lao PDR and Cambodia (b) Training followed by action—'Kelantan Flood Disaster Management Conference, Kelantan, Malaysia'. The conference was attended by about 500 participants consisting of experts from various fields, agencies and institutions of government and non-governmental organizations, academia and also the victims. (c) Consultancy for strategy development for disaster management.—'Workshop on Hospital Disaster Resilience'—A one-day workshop acted as a platform to gather a total of 55 hospital staff as a focus group to discuss the issues related to the 2014 flood as the major concern for the hospital preparedness (d) 'Project for community based resilience building—Reducing Flood-Related Food Security Challenges through ESD in Kuala Nerang, Kedah, Malaysia'—The stakeholders involved in this project consisted of experts from USM, residents, local officials and selected schools in the district. In order to provide better coordination of community engagement, USM now has a dedicated multi-storey building, the Toray Centre for Knowledge Transfer on campus.

3 Conclusion and Recommendation

Since achieving the APEX status in 2008, USM has been actively promoting and implementing ESD through systematic realignment of its priorities, curriculum changes, innovative research approaches, networking, community engagement, and dialogue between the academic community, policymakers and other stakeholders. This expanded sustainability implementation model shows the centrality of ESD in promoting education in its broadest form to build capacity for overcoming major ecological, economic and social challenges in a coherent and interdisciplinary way. In order to consolidate and strengthen engagement USM now has a new 'sustainability policy' which is the result of almost a decade and a half of implementation experience. Policies which are backed by data and success stories are better able to empower institutions to integrate solution oriented action. This realization has been confirmed by the results of the face one the APEX award and its continuation by the Ministry of Education as face two. Part of the lesson that was learned was that unless rhetoric is backed by action even the most grandiose ideas, such as ESD, will not fly high. The diverse activities focused on staff and student at USM have to be seen within this context. The improved autonomy, funding mechanisms, booklets providing ideas for fast tracking sustainability and a computerized methodology to monitor sustainability integration called SAM seem to make collective action that much easier. However, there are still delays and difficulties arising from a mix knowledge, perception, mindset and overall policy applications. The major challenge during GAP will be to overcome these barriers and to enhance the drivers. While there is no illusion that this will be easy, there is also no need to doubt the power of determination and networked action.

In view of its successes thus achieved so far, USM is now focusing its efforts on becoming a Global University (UG) under APEX 2020 which is a part of APEX Phase II strategy framework. Towards that mission, USM needs to achieve the eight main characteristics of a UG which are: global mission, knowledge production, new roles of faculty, diversified funding, multi-sector linkages, worldwide recruitment, complex university organisation and global collaborations. Sustainability agenda highlighted in the context of global mission, USM for example would focus on the realisation of a UG by giving emphasis on WEHAB+4 (W-Water, E-Energy, H-Health, A-Agricultural, B-Biodiversity)+(Climate Change/Disaster Management; Population Well-Being/Poverty; Production/Consumption; Waste Management) in aligning with the aspirations of the Sustainable Development Goals of the United Nations (UN) to reflect that the mission of USM parallels the mission of UN. To date, there are nine USM sustainable commitments at this moment and the future that demonstrated the ability of USM as a UG in the context of sustainability includes; Sustainable Development Policy, Sustainability Road Map, SAM and World Sustainability Assessment (WUSA), Pimpin Siswa, WEHAB framework, MSDP, Minor in Sustainability, RCE and CGSS. Besides, USM would be developing nexus groups in knowledge fields of strength which are related to various current national issues, to facilitate the sharing of expertise and collaboration in various fields of knowledge. USM would also refocus on doing research under themes which are closely-related to current issues, in dealing with the challenges of socio-economic development by establishing different nexus groups in areas such as urbanisation and urban poverty, social well-being and ageing (senior citizens), environmental sustainability, disaster management and raising the effectiveness in the process of public sector delivery.

We hope that the integration of GAP strategies and mechanisms in APEX Phase II ecosphere will strive to change the landscape of university to become a relevant institution that serve as custodian of the global sustainable development agenda in the 21st century. The USM APEX ecosphere and GAP roadmap are hope will succeed in mobilise other university to (i) mainstream the ESD in the educational system, (ii) integrate sustainability principles into education and training settings, (iii) increase the capacities of educators and trainers to more effectively deliver ESD, (iv) multiply the ESD actions among students, and (v) scale up the ESD programmes and multi-stakeholder ESD networks. We also hope that the Global Action Programme, launched at the World Conference on Education for Sustainable Development in Aichi-Nagoya, Japan, will succeed in mobilizing universities to strengthen ESD and provide practical guidance for effective implementation. Consequently, it is hoped that each university and its communities will be empowered to take informed decisions and action for ecological stability, economic progress and social inclusiveness and cultural diversity for the present and future generations. In this context, we are aware of the importance of monitoring and evaluation of our activities in the five GAP areas, as we have described, to promote enhanced ESD practice in Malaysia.

References

Arizona State University. (2009). Universiti Sains Malaysia: Leader in bringing sustainability to the forefront in Malaysia. Retrieved from https://universitydesign.asu.edu/db/universiti-sains-malaysia-leader-in-bringing-sustainability-to-the-forefront-in-malaysia

Dictus, R. (2015). How will volunteers help meet sustainable development goals? Devex. Retrieved from https://www.devex.com/news/how-will-volunteers-help-meet-sustainable-development-goals-85160

Osman, O. (2010). Making students' parliament a reality. Retrieved from http://202.170.56.249/index.php/en/news-archive/7299-merealisasikan-parlimen-mahasiswa.html

Osman, O., Ibrahim, K., Koshy, K., & Muslim, M. (2014). The institutional dimension of sustainability: Policy response for enhanced practice at Universiti Sains Malaysia. In P. B. Corcoran & P. B. Hollingshead (Eds.), *Intergenerational learning and transformative leadership for sustainable futures*. Wageningen, The Netherlands: Wageningen Academic Publisher.

Osman, O., Mey, S. S. C., Ibrahim, K., Hassan, H. A., Ghazali, M., & Koshy, K. C. (2016). The role of solution-oriented knowledge transfer programme and networking in charting a new course in University-Stakeholder engagement. In *Engaging stakeholders in education for sustainable development at University level* (pp. 243–262). Switzerland: Springer International Publishing.

Sibly, S., Rahim, A. A., Fizri, F. F. A., Manaf, N. A., & Othman, M. (2014). Sustainability assessment methodology: Measuring Universiti Sains Malaysia's transformation to a sustainability-led University. In *Intergenerational learning and transformative leadership for sustainable futures* (p. 329). Malaysia: Penerbit USM.

UNESCO, E. (2015). *Global action programme on education for sustainable development information folder*. Paris: UNESCO.

Universiti Sains Malaysia. (2008). *Transforming higher education for a sustainable tomorrow*. Malaysia: Penerbit USM.

Universiti Sains Malaysia. (2010). *Transforming higher education for a sustainable tomorrow 2009: Laying the foundation*. Malaysia: Penerbit USM.

Universiti Sains Malaysia. (2011). *Transforming higher education for a sustainable tomorrow 2011: Delivering excellence: World's first initiatives*. Malaysia: Penerbit USM.

Universiti Sains Malaysia. (2013a). *The Apex University: The state of the art*. Malaysia: Penerbit USM.

Universiti Sains Malaysia. (2013b). *The Apex University second phase: 2014–2025. Version 1.0. A consultative document*. Malaysia: Penerbit USM

Universiti Sains Malaysia. (2014). *USM policy on sustainability*. Malaysia: Penerbit USM.

Working for Sustainability Transformation in an Academic Environment: The Case of itdUPM

Carlos Mataix, Sara Romero, Javier Mazorra, Jaime Moreno, Xosé Ramil, Leda Stott, Javier Carrasco, Julio Lumbreras and Inmacula Borrela

Abstract

The Innovation and Technology for Development Centre at the Technical University of Madrid (itdUPM) in Spain is a collaborative network of lecturers, research students and non-academic professionals with a common interest in promoting action research for sustainable development. This paper is based on an in-depth analysis of itdUPM's co-evolutionary design process. The study is presented as an example of an inter-disciplinary environment that has been established for the co-creation of innovative technical and organisational solutions to address sustainable development challenges. The aim of this paper is to offer a case study of a collaborative technology and sustainability centre at the

J. Carrasco
Innovation and Technology for Development Centre, Department of Organizational Engineering, School of Industrial Engineering, Technical University of Madrid (itdUPM), Madrid, Spain
e-mail: javier.carrasco@upm.es

C. Mataix (✉) · S. Romero · J. Mazorra · J. Moreno · X. Ramil · I. Borrela
Innovation and Technology for Development Centre, Technical University of Madrid (itdUPM), Madrid, Spain
e-mail: carlos.mataix@upm.es

S. Romero
e-mail: sara.romero@upm.es

J. Mazorra
e-mail: javier.mazorra@upm.es

J. Moreno
e-mail: jaime.moreno@upm.es

X. Ramil
e-mail: xose.ramil@upm.es

I. Borrela
e-mail: inma.borrella@upm.es

W. Leal Filho et al. (eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education*, World Sustainability Series,
DOI 10.1007/978-3-319-47895-1_24

Technical University of Madrid (UPM), in Spain. Two focus areas are emphasised: the action research process chosen for the establishment and development of a networked centre, the Innovation and Technology for Development Centre (itdUPM), within the dominant disciplinary culture of a University organised along traditional lines, and the Centre's organisational design features which have proven to be appropriate for the inter-disciplinary and multi-actor action research processes necessary for addressing the challenges of creating a more sustainable society. The methodology used draws on theory to explore the Centre's development which is conceived as an evolutionary, participative, and action research process. The paper presents the context, background, design, and launch features of the itdUPM. The main lessons learnt refer to five organisational design issues that were critical for the success of the Centre and its activities. The paper describes the issues and challenges faced by the Centre as a "niche" operating in a dissimilar "regime". Although the findings are specific to the UPM context, we believe that they can inspire and stimulate other Universities interested in the development of sustainability initiatives.

1 Introduction: Universities and Transformation for Sustainability. *Beyond "Greening" the Campus*

The Sustainable Development Goals (SDGs) approved by the UN in September 2015 represent an ambitious and universal international commitment: ambitious, because their achievement implies a process of transformation that extends to all facets of human activity, at individual, social, productive, regulatory and governance levels; universal, because the goals demand responsibility from each and every individual, organisation and government throughout the world (United Nations 2014).

L. Stott
Innovation and Technology for Development Centre, International Master in Sustainable Development, EOI Business School, Technical University of Madrid (itdUPM), Madrid, Spain
e-mail: leda.stott@upm.es

J. Lumbreras
Innovation and Technology for Development Centre, School of Organizational Engineering, Technical University of Madrid (itdUPM), Madrid, Spain
e-mail: julio.lumbreras@upm.es

The SDGs follow in the wake of the Millennium Development Goals (MDGs) that were approved in 2000. The MDGs demonstrated that governments are able to set common and measurable development objectives and collaborate for their achievement. The agreement around the 17 SDGs and their 169 targets thus seems to be an appropriate way to promote a renewed sense of common direction and action. However, setting objectives to fight the effects of poverty in the way that the MDGs did (for example in terms of reduction of hunger or the promotion of access to clean water), is not the same as changing the direction of human development in order to achieve a sustainable future, particularly as sustainability is embraced as a very wide concept in the SDGs. A transformation for sustainability implies going beyond business as usual. This is not just a matter of increasing aid flows from "developed" to "developing" countries (Nicolai 2015); it is a complex process that demands rethinking technical and economic infrastructures, values and practices. In this context, higher education institutions have an important role to play.

Interest in the role of higher education institutions in the transition towards sustainability is not new. The "GUNi" (Global University Network for innovation) annual reports, for example, show an evolution in focus from education for development towards action for effective change. In line with this increasing awareness of "transformation for sustainability", many universities have introduced research, education and action programmes aimed at contributing to sustainability transformation. As a result, a range of integrated and holistic sustainability programmes are being put in place. This trend has been reinforced by the encouragement of academic networks such as the International Sustainable Campus Network (ISCN).

Many of these programmes are, however, too narrow and represent isolated "greening" initiatives. While largely due to the predominant view that sustainability is a concept limited primarily to its environmental dimension, this is also coupled with a traditional and strongly established approach that promotes unidisciplinary knowledge in both research and teaching. Moreover, sustainability efforts usually emerge in isolation and remain so because they are unable to generate sufficient interest within current university systems.

While there are clearly important challenges that limit university engagement in the sustainability agenda, it is also true that universities are well-suited to offer spaces that encourage the inter-disciplinary and multi-actor collaboration needed to support transformation. Indeed, both inter-disciplinary and multi-actor collaboration have seemingly been prevalent in the sustainability initiatives and strategies boosted by universities. This is, in fact, the sort of language that is widely applauded in formal academic discourse and appears to be a key element in the symbolic exercises that organisations and universities engage in Alvesson (2013). However, the practical reality tends to be somewhat different. As Stirling has recently pointed out, the intensity with which inter-disciplinary initiatives are proclaimed is not often matched by the reality of how research organisations operate and the incentives for working in this way (Stirling 2015).

The “implementability” or conditions that enable the change process towards the practical realisation of genuine inter-disciplinarity cannot rest on “top-down” institutional agreements; they require a process of integration (Bursztyn 2013). In our experience two complementary and connected change processes are needed: one that moves away from a conventional “silo structure” towards an inter-disciplinary environment; and another that shifts the campus towards diverse open “communities” suitable for co-production and the transfer of new kinds of practical knowledge that the SDG agenda requires. The possibility of accomplishing both pathways is dependent upon a range of organisational and cultural factors within universities. These include: the existence of personal purpose and leadership (at least from a few faculty members); an open-minded culture; organisational flexibility and cooperation skills.

In this context, the purpose of this paper is to share the experience of the Innovation and Technology for Development Centre at the Technical University of Madrid (itdUPM) in Spain, in implementing the kind of collaboration that we believe is necessary for the achievement of the SDGs. More specifically, its aim is to discuss the application of sustainability in the UPM, emphasising two key focus areas: the action research process chosen for the establishment and development of a networked centre within the dominant disciplinary culture of a University organised along traditional lines and; the Centre’s organisational design features which have proven to be appropriate for the inter-disciplinary and multi-actor action research processes necessary for addressing sustainability challenges in a collaborative and diverse environment.

2 Methodology

Yin (2008) points out that “a case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its reallife context, especially when the boundaries between phenomenon and context are not clearly evident”. In this sense, a case study is an appropriate methodology for achieving this paper’s purpose.

Two sources of information have informed this case study: Firstly, a review of the literature to explore relevant contributions to sustainability at Universities including organisational design, transitions theory and action research processes for sustainability. This material has provided the theoretical background for designing and guiding the overall experience of the case. Secondly, the researchers, as members of the Centre from its launch, have contributed information through an evolutionary and continuous process of internal action research.

The integration of thought and action has been a fundamental component of the itdUPM design process. This approach is founded on the belief that the conventional split between thinking and doing is not an appropriate way to deal with the kind of social problems faced by our society (Nelson and Stolterman 2012).

3 The Case of itdUPM. *From an Institutional Network to a Networked Organisation*

This section studies the origin, approach, purpose and activity of a special centre devoted to sustainable development: the itdUPM. The Centre represents an organisational innovation within the context of a state university operating along traditional lines.

The process of change experienced by itdUPM is that of a transition from an institutional network to a networked organisation. In line with transitions theory (Geels 2011) and its particularisation within the university domain (Robinson et al. 2013), we see this process as the emergence of a "niche" that is trying to evolve, be accepted by and, at the same time, influence the mainstream "regime" of the university as a whole. This "niche" has evolved from a set of research groups with a common interest in international development to an organised network of UPM community members and external experts collaborating together on sustainability challenges.

3.1 itdUPM. *Origin and Evolution*

UPM is a public university that was officially established in 1971. However, some of its Faculties were established much earlier, in some cases more than 100 years prior to this date. Today, UPM is the largest technological university in Spain. More than 40,000 students follow bachelor, master and PhD programmes in 17 Faculties (known as "Engineering Schools") and nine Research Centres, which are distributed across four different campuses in the capital of Spain, Madrid.

itdUPM's origins are rooted in the early 1990s. Three stages can be seen in its organisational evolution: firstly, a spontaneous, bottom-up development (1990–2000); secondly, institutionalisation (2000–2010); thirdly, integration and the creation of a network (2010-present) (see Fig. 1).

In its first spontaneous, bottom-up stage in the 1990s, a common interest in areas like water, agro forestry, energy and Information and Communication Technologies

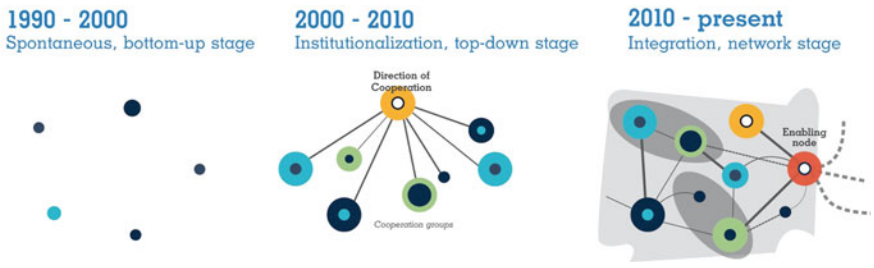


Fig. 1 The organisational evolution of International Development studies at UPM. *Source* The authors

(ICT), and their application in developing countries emerged among UPM researchers and students. In 1991, a group of these researchers established the NGO "Engineers without Borders Spain" and started to collaborate with other NGOs and international agencies.

Some years later, the UPM authorities decided to launch a specific organisational unit, the Directorate of International Cooperation for Development, under the Vice-Rectory of International Relations (institutionalisation, top-down stage). At this time in Spain a large number of budget increases in Official Development Aid created something of a "golden age" of development grants and funding sources. As a result, the Directorate of International Cooperation for Development established Cooperation Groups. Over 20 Cooperation Groups were soon working in this field, most of which were research groups focused on challenges in developing countries. These groups operated in a very diverse and fragmented manner. Some became internationally recognised groups, e.g. the "Hispano American Health Link," while others conducted their activities like small NGOs.

Perhaps the most interesting effect of the flourishing of these groups was the consolidation of a strong, informal inter-disciplinary network of researchers and faculty members. These individuals worked together with a shared interest and common purpose. They had a common understanding of the importance of creating a cooperative environment for the co-creation of innovative technical and organisational solutions to address development challenges. This was the breeding ground for the birth of itdUPM.

3.2 The Launching of itdUPM. *Vision and First Coordinated Lines of Action*

itdUPM was formally created in March 2012 as a new kind of organisational structure. In order to distinguish it from existing "Research Groups" and "Research Centres", itdUPM was defined as an "Innovation Centre". The aim was to create, within UPM, a new type of unit designed to promote inter-disciplinary and multi-actor collaboration in action-research. As the overarching intention was to be better prepared to offer appropriate solutions to the most common and recurring problems of poverty and sustainability, it was necessary for itdUPM to be:

- flexible enough to avoid blocking the ingenuity, spontaneity and identity of pre-existing organisational units and groups; while, at the same time,
- recognised as part of the formal structure of UPM so that it was not seen as a kind of "charity", particularly in the light of quite strong views that considered cooperation and sustainability as part of a "social action" add-on at the University rather than something embedded in its strategy.

The design of the new Centre was based on five basic features:

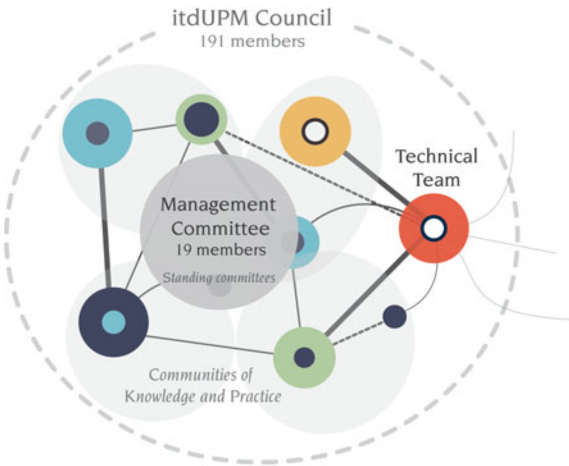


Fig. 2 itdUPM internal organisation (2016). *Source* The authors

1. Affiliation of a university researcher or faculty member to itdUPM would not be incompatible with their belonging to a Department or Research Group.
2. The internal organisation of the Centre would take the form of a specific network.
3. A single "feeder" node would ensure the launching and development of the network and assume the functions of external representation, communication and administration.
4. itdUPM would have specific, articulated and regulated decision-making bodies that were appropriately connected with the UPM authorities.
5. Non-academic professionals and experts with a record of collaboration with itdUPM and its groups would be welcome as affiliates.

It should be noted that one of these basic features, multiple affiliation of a person to several organisational units, was facilitated by the previous existence of Research Groups, which allowed a person to belong simultaneously to a Department and a Research Group. With the new arrangement, a faculty member is supposed to undertake teaching duties for their Department, disciplinary research within their Research Group and action-research with members of itdUPM's network.

These features guided the design of itdUPM's organisational architecture (outlined in Fig. 2).

Figure 2 shows the main itdUPM decision-making bodies, which are as follows:

itdUPM Council. Composed of 191 itdUPM members with diverse relationships to the UPM, includes professionals from organisations external to the University with whom a close connection exists due to work on joint projects.

Management Committee. Composed of 19 lecturers, including coordinators of Cooperation Groups and young PhD holders. The Committee also has a representative from the Vice-Rectory of International Relations (responsible for oversight of itdUPM). The Committee is elected by the itdUPM Council.

Standing Committees. Working under the Management Committee to speed up processes and programmes, they include the Quality Commission for the Master's Programme, the Management Commission for Experimental Spaces and the newly formed Management Committee Steering Group.

Technical Team (fulfils the enabler node function). A group of individuals dedicated exclusively to itdUPM under the auspices of the Management Committee.

Communities of Knowledge and Practice. Inter-disciplinary groups of teachers and researchers who apply knowledge from different disciplines to proposals and projects. Includes "communities" focused on energy, the use and application of big data, and resilience.

Inter-disciplinary and integrated projects were required to demonstrate the network's potential from the start. Emphasis was placed on projects with a scope and ambition that could not have been undertaken by a single research group. With this in mind, ten different Departments came together to work on a common project: the development of a Master's Degree in "Technology for Human Development". Although this was quite a challenge to UPM's traditional culture, the Master's Degree is now enrolling students for its sixth edition. With the involvement of the Complutense University of Madrid (UCM) in 2015, the degree has also evolved into an inter-university and inter-disciplinary programme that draws upon UCM's expertise in the field of social sciences.

itdUPM has also obtained various international contracts thanks to the experience of its researchers and the unique combination of competencies that it is able to offer. Inter-disciplinary projects in areas such as innovative and inclusive models of access to basic services (energy, health, water and sanitation) in Latin America and improvements to energy supply in refugee camps through partnerships involving the private sector, have been undertaken with multilateral institutions such as the Inter American Development Bank (IADB), the Office of the United Nations High Commissioner for Refugees (UNHCR), the Spanish Agency for International Development Cooperation (AECID), private technological companies such as Iberdrola and Philips, and corporate foundations such as the ACCIONA Microenergy Foundation.

Some findings and results (2016):

Inter-disciplinary orientation:

- Affiliation of 15 Cooperation and Research Groups from 14 different UPM Schools.
- Broad age range among the 191 itdUPM Council members (from 25 to 70 years).
- 30 pupils on the Master's Programme equally divided between those with a technical background/experience and those with a social background/experience.
- Transversal research themes such as big data, social impact and resilience.

Multi-actor collaboration orientation:

- 25 Master's classes open to the public involving professionals from partner organisations over the last three courses.
- Establishment of 12 strategic agreements with technological companies, international institutions and NGOs.
- International Conference held in June 2015 with support from ten organisations (businesses, corporate foundations, NGOs, communication agencies, professional associations of engineers, among others) and 452 participants.

4 Five Organisational Design Issues. *Critical Factors Are Human Factors*

During the four years since its creation, the organisational design of itdUPM has undergone an evolutionary learning process in which special attention has been given to five issues that appeared as critical organisational design factors for building an effective collaborative environment. These are: (i) a horizontal networked structure; (ii) a leadership style able to pilot the process; (iii) incentives that align participants; (iv) a cultural environment able to deal with several simultaneous identities; and (v) a virtual and physical interactive space that enables and fosters a sense of purpose and community as well as an open culture of trust.

4.1 Network Structure: *Don't Talk About Decentralisation, Practice It!*

To achieve its vision, itdUPM's promoters understood from the start that some kind of networked organisation was necessary. They thus defined a horizontal networked structure with clear and regulated decision-making bodies connected to the UPM authorities. The network's nodes were created on the basis of the pre-existing Cooperation Groups that had their own history and dynamics but whose activities would be enhanced by linking to the network. In addition, individual researchers, faculty members and non-academic experts were invited to join the initiative. This latter group sees the Centre as a vibrant community within which they find a creative atmosphere for working. Among other positive effects, the openness of the network has also fostered interest within the business community.

Once the Centre had been designed, a Technical Team was recruited. This team acts as a "feeder" node that nurtures the development of the network. The team also assumes the functions of external representation, communications and administration for the Centre.

A network is very likely to become a "foreign body" in an academic environment. The use of the word "network" may even be interpreted by many as synonymous with "messiness" and at risk of losing control. For this reason, a "sense-making" process was needed through which people could understand and experience the advantages of collaboration processes. itdUPM's sense-making process focused on how relationships evolve in an open network environment. It was promoted through workshops that were designed to make people "live" the dynamic interactions between departments and research groups, and external organisations. This process has included awareness-raising, training and targeted communication activities (Fig. 3).

In order to launch and promote itdUPM activities, specific personal and financial resources were necessary. To become a "feeder", the Technical Team has been

Fig. 3 Open sessions, conferences and workshops for itdUPM members and other professionals. *Source* The authors

essential for ensuring the internal and external cohesion of the network. A fee from contracts signed with public and private institutions covers team costs.

itdUPM's business model was defined on the basis of long-term collaboration. As well as working closely with public and private institutions able to offer financial support, this has also meant the inclusion of people who share common strategic interests with itdUPM and who are willing to interact with itdUPM members in co-working processes (Molas-Gallart and Tang 2011). As a result an external network has also been shaped. In parallel, a strong client focus has been developed that promotes reciprocity rather than simply looking for grants. itdUPM thus has strategic agreements with a number of selected public and private organisations with which they collaborate in research (particularly applied research) and training (through collaboration on the Master's degree).

Figure 4 shows the itdUPM organisation as a network connecting people and complementary groups with different roles: individual researchers, faculty members, universities and research centres from other countries, as well as non-academic experts.

Fig. 4 The itdUPM network environment. *Source* The authors

This structure presents strong similarities with the “Star Model” proposed by Bursztyn and Drummond (2013). They define three different levels of connection within the University: some connections are located in disciplinary departments (Research and Cooperation groups in the itdUPM model); others play a bridging role (such as that of the itdUPM Technical Team); and a third group is formed by those with interests and skills in inter-disciplinary methods and practices (similar to the role played by itdUPM affiliated researchers).

4.2 Leadership and Governance: *From Ego-Systems to Eco-Systems*

As explained above, itdUPM depends organically on the UPM authorities. However, with regard to its plans and activities it functions as a horizontal network and does not have a vertical central node that exerts power over the rest of the nodes. In line with organisational theory it could thus be considered as a sort of holacracy (Robertson 2015). This kind of structure requires a type of distributed leadership and the development of sound self-management capabilities (Laloux 2014). In this respect, and depending on the type of decisions, itdUPM has different leadership styles (as shown in Fig. 2):

- Decisions are taken by consultation in committees such as the Management Committee, the itdUPM Council or the Quality Commission for the Master’s Programme.
- Decisions are taken by consensus in “Communities of Practice”, which include faculty, students, representatives from business and public bodies, as well as Technical Team personnel.
- Decision processes concerning proposals; team composition and supervision of specific projects are designed and undertaken in an ad hoc manner.

None of the cases outlined above involve an “ego-system” leadership style. Moreover, given that “super egos” do not fit within its culture, itdUPM’s is moving “from ego-systems to eco-systems” (Scharmer and Kaufer 2013). Such a culture requires: the silent promotion of increased personal autonomy and decentralised leadership; emphasis on creating a sense of community and purpose; far reaching transparency and accountability, and the promotion of self-criticism, rather than sanctions, as the most appropriate way to ensure continuous improvement.

The governance of itdUPM is based on transparency and participation. All the decision-making bodies mentioned above carry out their work in an agile and transparent manner and receive strong support from the Technical Team. The Centre also has a Director who was appointed by the Rector after a Council Hearing. The Director is, with the support of the Management Committee, responsible for external relations and communication, new project promotion and contracts, as well as supervision of the technical node of the network.

It is also important to highlight the intermediary role played by a range of individuals in the development of itdUPM. The Director of the Centre and members of the Management Committee have engaged in an ongoing process of dialogue and engagement with University authorities in order to position the Centre as an integral and valuable part of the University system. Not only have these efforts guaranteed institutional support for the Centre, they have also created a positive enabling environment for its work.

4.3 Incentives: *When Only Intrinsic Motivators Are Available*

Motivation is what moves us to action. In the case of itdUPM, traditional coercive incentives (money and employment) do not exist because the contracts of professors and lecturers do not depend in any way on itdUPM. The motivation for belonging to the Centre thus relies on its appeal and interest. Its central attraction derives from its purpose (contributing to sustainability), its vision and its collaborative atmosphere. For this reason, open affiliation was a critical element in itdUPM's design.

From the beginning, membership for any UPM faculty member has been based on an individual, personal basis with affiliation made fully compatible with other School, Department, Research Group or Cooperation Group linkages. A number of early candidates were members of existing Cooperation Groups. To enable this possibility, the new Centre was granted a special status by the UPM authorities.

Members of the itdUPM Council, which meets twice a year, agree upon the acceptance of new candidates. As affiliation is voluntary, if the activities are not attractive enough for a given member, she or he can leave by presenting their formal resignation or simply ceasing to participate in itdUPM's activities.

Membership includes a certain personal risk. Inter-disciplinary research papers, for example, still face publication difficulties (Rafols et al. 2012). At the same time, the development success of the new venture has at times been quite insecure due to the budget restrictions affecting the Spanish public sector as a result of the financial crisis. Drastic spending reductions for research and very limited financial support from the UPM for the new Centre have meant that it has been a real challenge to make it grow, reach critical mass and become acknowledged by the rest of the UPM. In some ways, however, this challenge has also been an incentive for membership. Fortunately, many of these difficulties have now been overcome: membership currently exceeds 190 people in total and a more solid financial income enables the Centre to function well.

Many of the Centre's members have stated that the chance to interact and collaborate with members of different disciplines and external professionals in action research projects has been a great incentive for joining itdUPM. In this respect, the early launch of several multi-disciplinary and multi-actor activities and projects has provided itdUPM with credibility and important backing. As an example, during the last Council meeting, a diverse group of eight members, from young researchers to professors, enthusiastically shared their experience of working with itdUPM, some of their testimonies are reproduced in the following chart.

> Previously I felt that I worked in an excessively hierarchical manner; a teacher working more or less on my own. This new phase of working with the itdUPM is extraordinarily interesting and revitalising for me and I am learning a great deal about how inter-disciplinary groups can change the way we do things in the University. (Miguel Ángel Egido, Senior Lecturer, Institute of Solar Energy, School of Telecommunications Engineering)
>
> I love working with itdUPM because it's a space in which we encourage one another not to be afraid of failing… In the coming years, after completing my PhD, I would like to develop my academic career in this fresh, flexible and different space… and include our students in this… (Inma Borrella. PhD Assistant Teacher, School of Industrial Engineering)
>
> In the Centre I have met friendly people with a great capacity for change… (Jaime Cervera, Chair of the School of Architecture)

Other motivations for joining the Centre are more emotional in character and include trust, a shared passion for a theme of interest and a warm atmosphere. In preliminary surveys among the itdUPM community, belonging to a voluntary, challenging and vibrant learning community appears to be one of the main reasons for wanting to participate in the network.

We are aware, however, that the motivations cited above may not be enough to ensure long-term participation. As it expands, and with greater recognition for the Centre, other incentives directly related to the professional careers of researchers are increasingly important. The growing number of scientific papers published in relation to itdUPM projects demonstrates this trend.

4.4 Identities: *How to Wear Two or Three Hats Simultaneously?*

Collective identity stems from the interpersonal interactions that make up an organisational culture. The main pre-condition for enabling the development of itdUPM as a horizontal network with its own culture within the UPM was its official acknowledgement by the UPM authorities as an "innovation centre" endowed with a specific status.

UPM faculty members are used to belonging to a diversity of organisational units: Schools are the most traditional, permanent homes; Departments, for teaching purposes; and, Research Groups, for disciplinary research activities. In this context, the key was to specify that itdUPM had a different aim, namely, to develop innovations by adopting a multi-disciplinary, multi-actor action-research approach.

In this way a faculty member can engage in disciplinary research in his/her Research Group and collaborate with members of other disciplines and external professionals for innovation purposes in itdUPM.

The development of both an itdUPM culture and a new membership identity was carefully managed by its Director and enabled by the Technical Team via network communications and workshops. Through this process, a shared itdUPM culture has taken form and the Centre's identity has become interiorised by its members.

The culture of the Centre and the new membership identity were reinforced by the design of a logo linked to that of UPM. This "corporate identity" is used in the Centre's network messages and web diffusion spaces, including its website www.itd.upm.es, as well as in the social networks—Twitter, YouTube, SlideShare and LinkedIn.

4.5 Common Spaces: *Where There Is a Will There Is a Way*

Since its inception, the activities undertaken by itdUPM have encouraged members to act as a community of researchers and practitioners that focus on understanding contemporary society through a trans-disciplinary approach to solving key social problems. This, in turn, promotes the co-generation of innovative courses of action that can, as far as possible, be implemented and spread more widely.

The Centre began without an appropriate physical space and has, to date, relied simply on will to pursue its activities. The small office from which it operates has clearly been insufficient, even with the additional use of rooms that have been kindly lent by other Schools at the University. As a result, the idea of designing a project that could be an expression of "regenerative sustainability" (Robinson 2013) emerged: a working space to encompass the kind of organisational model that we wish to pursue.

Inter-disciplinary conversations among researchers and experts were held to explore this idea further. One of the suggestions was the use of the campus as a place for experimentation in sustainable technologies and behaviours. These conversations suggested that a sustainable future for itdUPM might more easily be achieved if it was reinforced by the construction of a bioclimatic building located at the heart of the main university campus (International Excellence Campus Moncloa). Architects (experts in bio-climate buildings), agronomists (experts in urban agriculture), engineers (experts in solar energy and water), and students were then brought together to develop a project that was finally approved in July 2015.

The itdUPM building has now been constructed. It will not only serve as the headquarters of the itdUPM but also as an open demonstration space devoted to spreading technologies and innovations for sustainability. Concepts and prototypes for urban agriculture, decentralised energy systems and the circular economy, among others, will be tested there. In parallel to the construction of the physical infrastructure, scientific and dissemination activities that will take place in this new facility are also being designed.

Fig. 5 The itdUPM building: Pictures of the itdUPM collaborative building process. *Source* The authors

This new physical facility is already attracting the interest of several actors, for example, the network of urban orchards. Several firms have also expressed a wish to use the space to test technological prototypes. Once the facility is available, it will ease multi-actor relationships and the interchange of experiences with the large number of social innovation spaces promoting citizen's involvement that are currently emerging in Spain and elsewhere (Fig. 5).

5 (Non-Definitive) Conclusions. *Co-Evolutionary Design Process*

The Innovation and Technology for Development Centre that is in place today is the result of an evolutionary organisational design process based on the previous experience of a network of researchers focused on sustainability. An ongoing process of permanent learning and adaptation has been put into practice.

In consequence, any conclusion to this study must be considered as preliminary and in need of fine-tuning. Indeed, conclusions may also need to be abandoned altogether as itdUPM, and other similar initiatives, accumulate, share and analyse their different trajectories and experiences. Bearing this in mind, we nonetheless believe that the following observations are worth sharing.

The creation of collaborative inter-disciplinary and multi-actor spaces has not been a simple task. It has involved a complex design process requiring careful decisions with regard to organisational and human factors such as leadership style, culture and values. In this sense, three lessons can be underlined:

- Solving the potential problem of multiple identities for affiliates from the start was a precondition for success.
- The promotion of self-management capacities and a distributed leadership style have been critical for the attractiveness of the Centre, its growth and the extension of its activities.

- The Centre's collaborative atmosphere and its sustainability focus have proved to be the most appealing incentives for potential members.

Relevant and specific capacities were needed to pilot the launch, not only in terms of financial resources but, above all, in terms of human resources and institutional support. A dedicated team has been crucial to the development of the internal and external network and to nurturing its fragile ecosystem. The process has also required a long time to mature before being able to count on a genuine change management process in which behaviors, relationships and practices moved from those typical of a conventional university environment to those that are appropriate in a more collaborative and diverse environment.

The institutional anchoring of the Centre in the UPM has been crucial to its success. The formal status of the Centre is dependent upon the highest representative of the University: the Rector. At the same time, beyond this formal relationship, the promotion of itdUPM rests upon its personal relationship with the University authorities. This latter connection involves informing and, where possible, involving them, in the strategic decisions of the Centre.

itdUPM's integrative role has been mirrored in the way that external relationships have been built with companies, international organisations and NGOs. Beyond the traditional "extractive perspective" (institutions should support a university that works for sustainability), the Centre has developed a "mutual reciprocity perspective" (universities and other institutions need each other in order to address problems that affect all of them). In this sense, an advanced "client perspective" has been very important for adapting itdUPM training and research services to the real needs of its partners. As a result, a network of long- term relationships has established the basis of a sustainable business model for itdUPM.

Having completed its institutional infancy, itdUPM now faces new challenges. The organisational model based on a lean and horizontal structure needs to be expanded in order to demonstrate that it can scale-up without a centralised control structure. Moreover, its very success may jeopardise the itdUPM initiative, especially if the growing expectations it has created cannot be satisfied, or if the increasing visibility of the Centre is perceived as a threat to dominant unidisciplinary interests.

As Sennett (2012) points out, after decades of obsessive competition we have harmed our capacity for cooperation. At a time when transformation for sustainability is both urgent and desirable, universities have the opportunity to unleash some of the social creativity and clarity needed to find new and better development pathways.

Acknowledgments We would like to thank Manuel Sierra, Carlos Gregorio Hernández, David Pastor, Xoán Fernández and Leonardo Martins for their comments on this paper.

References

Alvesson, M. (2013). *The triumph of emptiness: Consumption, higher education, and work organization*. OUP Oxford.

Bursztyn, M., & Drummond, J. (2014). Sustainability science and the university: Pitfalls and bridges to interdisciplinarity. *Environmental Education Research, 20*(3), 313–332.

Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions, 1*(1), 24–40.

Laloux, F. (2014). *Reinventing organizations*. Lannoo Meulenhoff-Belgium.

Molas-Gallart, J., & Tang, P. (2011). Tracing productive interactions to identify social impacts: An example from the social sciences. *Research Evaluation, 20*(3), 219–226.

Nelson, H. G., & Stolterman, E. (2012). *The design way: Intentional change in an unpredictable world: Foundations and fundamentals of design competence* (2nd ed.).

Nicolai, S., Hoy, C., Berliner, T., & Aedy, T. (2015). Projecting progress: reaching the SDGs by 2030. *London: Overseas Development Institute*.

Rafols, I., Leydesdorff, L., O'Hare, A., Nightingale, P., & Stirling, A. (2012). How journal rankings can suppress interdisciplinary research: A comparison between innovation studies and business and management. *Research Policy, 41*, 1262–1282.

Robertson, B. J. (2015). *Holacracy: The new management system for a rapidly changing world*. Macmillan.

Robinson, J., Berkhout, T., Cayuela, A., & Campbell, A. (2013). Next generation sustainability at the University of British Columbia: The university as societal test-bed for sustainability. In *Regenerative Sustainable Development of Universities and Cities: The Role of Living Laboratories* (pp. 27–48).

Scharmer, C. O., & Kaufer, K. (2013). *Leading from the emerging future: From ego-system to eco-system economies*. Berrett-Koehler Publishers.

Sennett, R. (2012). *Together: The rituals, pleasures and politics of cooperation*. Yale University Press.

Stirling, A. (2015). Developing 'Nexus capabilities': Towards transdisciplinary methodologies. Draft discussion paper. Nexus Network Team, SPRU and STEPS Centre.

United Nations (2014). The road to dignity by 2030: Ending poverty, transforming all lives and protecting the planet. Report of the UN Secretary General, New York.

Yin, R. K. (2013). *Case study research: Design and methods*. Sage publications.