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Teaching and Learning

► Curricular Innovation for Sustainability

Technological Enhancement and Sustainability

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Definition

Technological enhancement and sustainability can be defined as 'improving the results of higher education through the use of information and communication technologies in a sustainable way'.

Introduction

As higher education becomes more important and affordable, and the costs of hiring teachers on the increase, there is a need to find sustainable ways that allow students in higher education to better achieving their learning outcomes, without using methods such as small-class teaching or distance learning. e-Learning can be the answer to this problem. The idea of e-learning and its applications have gotten impressive consideration lately. While many teachers at schools from primary schools to colleges know about this new learning mode, many are still dubious whether the selection of this innovation for learning would be appropriate for them. Instructors who need to embrace e-learning might not have obtained the adequate information and experience to adjust their present instructing strategies to leverage the advantages of this new method of learning. The purpose of this chapter is to furnish teachers with an outline of the distinctive types of e-learning. The possibilities of e-learning will be inspected to uncover its significance to instructors and students. This chapter will begin by explaining the increasing demand for higher education, not just by secondary school leavers but also by working adults who may already have obtained some professional qualifications. Then it will introduce the role of e-learning in higher education, and mobile learning as a special form of e-learning. After that, it will review the use of clickers, a practice which is becoming popular among tech-savvy teachers. Then it will review another trend in e-learning – Massive Open Online Courses. Finally, it will conclude by reviewing the best way to use technology for sustainability in higher education – blended learning.

The Importance of Life-Long Learning

To be successful in today's knowledge-based economy, even university graduates who have completed

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their formal training frequently need time to do life-long learning. This keeps themselves acquainted with the learning they gained in school and to stay up to date with the advances and most recent improvements in their own fields. On the contrary, when there is an absence of adequate continuous education, one may be unable to cope with new situations. In some cases, this may result in losses in monetary terms or even human lives. There are some examples in the medical sector in Hong Kong that reflect the significance of this point. When a patient was hospitalized for throat removal procedure and a tracheostoma surgery to make a breathing hole for him in 2011, all the three medical attendants who were dealing with the patient thought the tracheostoma was only a transitory one, and therefore applied adhesive tapes all around it. The patient lost his life 72 h after the medical procedure (Yeung 2016).

Hence, it is clearly necessary for working adults to keep on learning after they have completed their formal instruction. This chapter will provide an outline of different contemporary e-learning approaches. It will start with Learning Management Systems (LMS). Then it will discuss more recent developments such as Mobile Learning, Clickers, and Massive Open Online Courses (MOOCs).

What is e-Learning?

There are no universally accepted definitions for e-learning (Moore et al. 2011). It can be argued that learning that is assisted by a CD-ROM, the Internet or an Intranet, audio- and videotape, satellite broadcast, or interactive TV are also forms of online learning. However, some authors adopted a more restrictive view and suggested that e-learning is a form of online learning. The American Society for Training and Development defines eLearning as "anything delivered, enabled, or mediated by electronic technology for the explicit purpose of learning" (Kirk 2002, p. 4). For the purpose of this chapter, we define e-learning as "the acquisition of knowledge which is enhanced or enabled by the use of technology".

The need for eLearning has been growing around the world. There are two main approaches in using e-learning. In the first approach, e-learning can be part of a course taught in a traditional classroom. For example, a subject for one semester conveyed by a college. In the second approach, e-learning can be used by aspiring students to learn individually at their own pace. The later approach is especially suitable in today's fast-paced societies. Many working adults do not have the time to take formal classroom course, yet they want to learn at their own pace so as to pick up the information and abilities to improve their career.

Mobile Learning

Mobile learning is a type of eLearning. It is common to see people reading, and responding to, messages on their mobile phones during their commute or during other periods of spare time. The market for mobile learning has been expected to grow at a steady compound annual growth rate of nearly 19% (Pappas 2015). Mobile learning can be characterized as "a ubiquitous learning activity supported by the appropriate mobile technology and pedagogical approach" (Lin et al. 2014, p. 341). It has been found that students can use their mobile phones for learning, they are more engaged in the learning than the traditional "chalk-and-talk" methods. Thornton and Houser (2005) compared two groups of students. One group of students were given exercises via a series of cellular phone messages, while another group received printed handouts of the same exercises. The final scores showed that the mobile learners performed better on examinations. Furthermore, Thornton and Houser (2005) found that the average Japanese university student sent 200 text messages per week using their smart phones, but they only made seven voice calls. The definition above begins with the word "ubiquitous" to emphasize that the learner can use the mobile phone to study anywhere. While this is true, teachers often forget the usefulness of the mobile phone inside the classroom, and they under estimate the willingness and ability of the learner to use the mobile phone as a learning tool. The following section will review how the mobile phone can be used in the classroom for more effective and efficient teaching.

Clickers

Traditionally, in classroom teaching, teachers can perform one or two formal tests, and some classroom verbal questioning to check how well the students understand the course. As higher education becomes more affordable, many students can have access to higher education. This creates a challenge to the teacher because the students in the classroom are not necessarily all elites. When a teacher asks a question, only the few very confident students will answer the question. When the teacher invites students to raise questions, most of them will not ask any questions. This question aversive behavior is more common in Asia, where students do not want to lose face in front of their peers. Hence, the teacher needs to have a way to quickly find out how well each student understands the lesson immediately during the lesson (Micheletto 2011; Wang et al. 2009).

As digital technologies become more advanced and affordable, some teachers begin to collect immediate responses from mobile devices controlled by students in the classroom. There are a number of names given to this kind of technology. These names include "Audience Response Systems," "Classroom Response Systems," "Personal Response Systems," and "Clickers." They were first used in Hollywood in the 1960s and to get immediate feedback from the audience when they viewed unreleased movies, commercials, and television shows. Hence, they were also known as "audience-response systems" (McLoone et al. 2015). Among these names, Clickers is the better known.

When they first emerged in the classroom, the clickers could only be used for answers of multiple-choice or true/false questions. That is because they only had a few keys by which students could choose their answers to the questions posted by the teacher. Then, the statistics of the students' answers were summarized and shown on the projector screen in real time. Thus, clickers were low-cost systems that allowed teachers to quickly get answers from the all students in the classroom. Students were no longer reluctant to answer questions because the whole class can see only the bar charts of student responses but not student names. Teachers were able to engage students even in a large class. With proper arrangement, it was also possible to track which student provided which answer to each question. The need for submitting and handling paper-based student work is reduced.

There is empirical evidence that the clicker could increase student interest (Nam and Cha 2012; Şad and Göktaş 2014). However, there are extra procedures involved. In many higher education institutions, the students can the clickers from the school. As each clicker has a unique code associated with each student response, many students may have concern about their privacy. This prohibits them from revealing their true opinions or behaviors in certain questions (Caldwell 2007). When they answer questions that are strictly confidential, such as those related to unethical behavior, special measures must be taken to assure students that their answers are indeed anonymous (Gikas and Grant 2013). For example, the teacher carries a box of clickers to the classroom, and then let students choose their clickers randomly. In many higher education institutions, the students can get the clickers from their schools. This is not sustainable as some students may not be willing to pay for the clickers. And for those who are willing to pay for it, they may forget to bring them to the classroom (Withey 2010). Furthermore, the clickers are limited to questions with only a few choices.

Instead of clickers, teachers have begun to ask students to use their mobile phones to respond to questions in recent years. This is gradually becoming popular although the mobile phone is heavier and bigger than the typical clicker. It is because the mobile phone can answer more types of questions, and almost all students already have a mobile phone. Students can enter text very efficiently on a mobile phone using the virtual keyboard. Thus, the teacher can ask open-ended or fill-in-the-blank questions. It is also possible to ask students to users to click directly on an image to respond to a question. This reduces the possibility of error in making a choice when choosing a number that represents part of an image. Mobile phones are small enough to be used in the classroom without adversely affecting note taking and peer discussions (Lindquist et al. 2007). A typical use case is that the teacher prepares some question on a website, and then the students visit the website using their mobile phones to answer the

questions. These systems are also known as mobile phone-based student-response-systems. As there is no extra hardware or special logistics involved, the mobile phone-based student-response is more sustainable than the clicker.

Overall, the clicker and its variant, the mobile phone-based student-response-system, is a sustainable way to deliver higher education. It is because it allows the teacher to teach a large class effectively, and it reduces the use of paper as a medium for submitting student work.

Massive Open Online Courses

The conventional classroom training normally happens at night or on Saturdays or even Sundays. In this mode of training, the trainer can interact with students, and the students interact among themselves. Most learners understand this mode of training very well, and they do not need to use or own special technology to benefit from it. However, it also means the learner must commute from their offices to the training venue at predetermined times. Certain institutions offer distance learning, in which students can have the teaching materials through the mail. Then they can learn at their own pace, complete the assignments, and then send them back to the institution. In many cases, this kind of learning is supplemented by TV broadcasts and telephone support. More recently, these distance learning courses take advantage of the Internet. That means students can download learning materials and submit their completed assignments via the Internet. Certain more advanced distance learning websites can also provide online discussion forums and online assessments However, in many cases, the website used by these institutions are not especially developed for distance learners. Furthermore, the students may have to learn to navigate and understand different website when they take up new courses. This creates a hurdle to the distance learners.

Massive Open Online Courses, which is also known as MOOCs, have emerged as a solution to this problem. Examples of popular MOOCs are FutureLearn, Udacity, edX, TreeHouse, Coursera, and HDX. Many of these are first created by universities. For example, MIT started the OpenCourseWare (OCW) initiative in 2001. Now they have over 2400 courses and 300 million visitors (Massachusetts Institute of Technology 2019). Stanford and Harvard are among the first universities that create their own open and free learning websites. Following the success of these university initiatives, companies, such as Microsoft or Google, and different organizations, such as IEEE or the Linux Foundation also created their own MOOCs. As a special type of online education, MOOCs consists of well-structured, mainly university-level, programs. Most MOOCs charge small or no fees. Since the Internet as a medium, they can take up massive amounts of learners. Furthermore, most courses in MOOCs do not have prerequisites. Therefore, they are open to all learners (Oudeweetering and Agirdag 2018).

To increase the attractiveness of their programs, some educational institutions even offer degree programs through MOOCs. One example is that the Georgia Institute of Technology cooperated with Udacity to offer an online master's degree. When students finish the online program, they can pay a fee to apply for a certificate which showed the same degree as the on-campus, instructor-led degree. However, the cost of the program on MOOC is only one-fifth of that of the on-campus degree (Bentz 2014, p. 146). Another example is MicroMasters program in International Hospitality Management offered by the School of Hotel and Tourism Management (SHTM) of The Hong Kong Polytechnic University (PolyU). According to PolyU, the program is the "first-of-its-kind credential" and "an accelerated on-campus program" (PolyU 2016).

The program is offered in the form of MOOC via the edX platform. Learners who successfully earn the MicroMasters credentials will be eligible to apply for the SHTM's Master of Science in International Hospitality Management program. The edX platform is a nonprofit online learning destination founded by Harvard and MIT. The program adopts an "inverted admissions process." In this process, a learner from everywhere can try master's level course work from the SHTM before committing significant time and money toward applying for and enrolling in a master's degree.

However, there is the worry that "the credentials for MOOC completion will cause confusion about higher education degrees" (Bentz 2014, p. 146).

There are advantages to the learner, as well as to companies and organizations that created these MOOCs or contribute to the courses in them. As of 2015, in excess of 350 organizations had utilized MOOCs to look for, among the relevant courses, the students who are suitable for fulfilling job openings. In particular, Google had registered more than 80,000 of its staff in MOOC courses relevant to website development (Pappas 2015). Although MOOCs are mostly free, flexible, and open to all, there are also some disadvantages. It was discovered that both the engagement rate and the finishing rate in MOOC courses are low. A research by the University of Pennsylvania on a sample of one million MOOC users, just about half of them really viewed the videos of the required addresses, and a bare 4% completed the course they signed up for (Bentz 2014). Another issue with MOOCs is that capabilities procured through MOOCs may not be acknowledged by bosses or training foundations. To solve this problem, blended learning is one of the solutions. In blended learning, the face-to-face and online distance learning elements are combined. That means some of the lessons are delivered in a traditional classroom, and some contents are delivered using websites.

Moving Forward with Blended Learning

Despite the advantages of mobile learning, clickers and MOOCs, there is no one single technology or method that can meet the leaning needs of contemporary learners. Therefore, the most sustainable solution is not to rely on one mode of learning but to combine, or blend, the modes and technologies that can best meet the needs of, and constraints faced by, the learner. Through blended learning (BL), the student can gain the latest information through an array of different types of learning modes. There are several modes in which different learning and teaching methods and educational technologies can be blended. In the first mode, the blending means the integration of several kinds of Internet-related technologies. These technologies may include virtual classrooms, self-paced courses, collaborative learning, video streaming, audio, and text. In the second mode, the blending means to combine different educational paradigms (e.g., constructivism, behaviorism, and cognitivism) to deliver the required learning goals with or without the use of technologies. In the third mode, any type of eLearning, even offline technologies (e.g., recordings, CD-ROM, online preparing) is blended with traditional classroom teaching. Finally, in the fourth mode, technology is blended with real-life tasks-at-hand to build an amicable environment of learning and working.

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Technological Innovation for Sustainability

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Introduction and Definitions

In this paper, we aim to discuss the role and importance of technological innovation for sustainable development. To do that, we divide our discussion in two major parts: First, we highlight the role of technological innovation as an engine for social prosperity and how it can alleviate and solve social and economic problems; second, we explore a range of possibilities regarding possible contributions that technological innovation can offer in solving or mitigating some of the major environmental sustainability problems of the present. The sustainable development concept was initially formulated and gained global attention since the Brundtland Commission (UNWCED 1987). Its first definitions comprised the following core sentences:

> Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
>
> Meeting essential needs requires not only a new era of economic growth for nations in which the majority are poor, but an assurance that those poor get their fair share of the resources required to sustain that growth.
>
> Sustainable global development requires that those who are more affluent adopt life-styles within the planet's ecological means - in their use of energy, for example." Further, rapidly growing populations can increase the pressure on resources and slow any rise in living standards.
>
> Yet in the end, sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs. (Source: UNWCED 1987)

Ever since, the sustainable development concept has always been closely intertwined with what later came to be the sustainability term and its equally important economic, social, and environmental triple bottom line proposed by Elkington (1997) and complemented by debates (Weisser 2017), on what is perhaps the most accepted broad definition of the term. More recently, the Department of Economics and Social Development of the UN (United Nations) also proposes a similar definition for sustainable development, that is:

> . . .the bridge, between environmental, economic and social goals, between north and south, between Governments, civil society and business, between science and policy, and between policy and action. (Department of Economics and Social Development (DESA) 2013)

Finally, the UN 2030 Sustainable Development agenda puts all its main goals as derived from a

people (social), planet (environment), and prosperity (economic) perspective (United Nations 2015). To summarize, all the above definitions of sustainability and sustainable development referred to closely dialogue and are centered in the joint advancement of these three pillars in a synergic and simultaneous way. All the complements after the 1987 definition should be seen as supporting the first one or enriching it.

As to technological innovation, according to the Oslo Manual (2005), which is nowadays still the international reference in terms of innovation research, an innovation is the effective implementation of:

> . . .a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations. (OCDE 2005)

Restricted to technological innovation, the manual's emphasis is mostly in new products, or services, or new processes innovations and its introduction to the market. It should be observed, however, that this definition comprehends and can also be applied to public services' or nonprofit organizations' products or services, for example, as we approach the sustainability issue in its three broader pillars and how technological innovations affect them.

Sustainability Pillars and Technological Innovation

People, Prosperity, and Technological Innovation

We chose to couple people and prosperity within a single topic when it comes to sustainability because of their close relationship regarding the broader impacts of technological innovation has in society. A list of the some of the most important areas is detailed in the following paragraphs.

Ever since the first Industrial Revolution in England in the eighteenth century, the pace at which new production and transportation techniques increases economic growth has dramatically accelerated. In a historically brief period of approximately 200 years, living standards have dramatically changed when compared to the previous history of mankind. As the historical distancing now allows us to see, first the experimental and later science-based technologies, coupled with the advancement of politics and methods of social organization, have produced exponentially growing results, way beyond those that could be imagined when the Industrial Revolution began.

Since the early days of the economics science, considered by many the initial publication of Adam Smith's work and theories, technical progress has had a central role in economists mentions about how society progresses (Freeman 2008; Nelson 2006). As time went by, technical and scientific progress became an even more complex undertaking. The application of new developed sciences to production and transportation methods became routine and the ties between science and technology grew each time stronger (Stokes 2005). The precursor of the economics of innovation Joseph Schumpeter recognized the pivotal role that this continual development and application of innovations had in economic progress and introduced his concept of "creative destruction." It refers to successive historical waves that qualitatively change the nature of production and society by disrupting the economic domain and then creating new order (Elliott 1985; Schumpeter 1934). Later, Solow (1957) tried to quantify the impact increases in labor and capital had in the American economy from the beginning until the middle of the twentieth century and found that most of the American economy growth could only have come from a qualitative, and not quantitative, improvement in the utilization of both.

The measure of the impact of technological innovation on economic growth can be more clearly observed by looking at the economic overview of the twentieth century. As shown in the IMF report published at the turn of the millennium, there's an estimate that shows that the production of goods only in the twentieth century, using a GDP (gross domestic product) measure of value, exceeded all the accumulated production in previous human history. Since the beginning of the century, the world GDP multiplied by 19 while world population grew by 4 times. Still according to this report, although both grew, the disparity between population growth and economic growth clearly exhibit the role technology and qualitative

economic changes had in this process. It is also important to highlight that this growth took place not only by improving the productivity in established industry sectors but also by creating and developing entirely new industries that accounted for much of this growth (IMF 2000).

It is widely acknowledged nowadays how important the continuous application of technological innovation is to increase levels of economic productivity and, therefore, enable good conditions of living for people resident in each country or area. It is through the advancement of science, technology, and its practical application in the form of technological innovations that humanity was able to support an over fourfold increase in its population since the beginning of the twentieth century. Without the advancements in land productivity, biotechnology, and machinery, among others, massive levels of hunger would nowadays be observed in most of the world, and food security levels, which are both economic and social objectives, would now be unsustainable (Kasturi 2009).

Among the UN 2030 Agenda, fostering technological innovation is put as one of the 17 central goals. It is seen as a way to upgrade national capabilities, especially when it comes to developing countries, and increase the offer and quality of jobs and a fundamental tool in overcoming other sustainable development challenges. To do so, the agenda calls for efforts of collaboration between more advanced and developing countries and the promotion of international knowledge diffusion mechanisms.

Apart from the pure economic and productivity growth roles of technological innovation, the modern technological developments in the most diverse fields have been responsible for significantly improving living conditions and corroborate diverse goals in the social pillar of sustainability. Examples of this kind abound. As such, we can highlight the pharmaceutical industry and its advancements in instruments, methods, and equipment of diagnostic, organic chemistry, production methods, and pharmacology that enabled the creation and dissemination of several new therapies. In a close interplay with advancements in science, technological innovations in medicine greatly improved the quality of life of millions of people around the world (Achilladelis and Antonakis 2001).

Here, it is also important to highlight the recent impact of the revolution in information and communication technologies (ICTs). These technologies have facilitated access to information in many parts of the world, with applications that range from media and social networks to education at distance. They also made it a lot easier for international companies and other organizations to coordinate economic operational activities that are spread around the globe, which hastened globalization and provided many developing countries with several opportunities of investment, employment, and use of their local competitive advantages that were previously inexistent.

However, the recent developments and cutting edge technological innovations also pose a series of challenges that will have to be addressed to avoid setbacks in the attainment of the sustainable development goals. Although technological innovations have brought many different benefits, there are still billions of people living in poverty and unable to reach the fruits it has brought to more developed areas of the world, one of the major challenges in then creating a governance and appropriate incentives so that, over time, more people have access to the benefits technology brings, in a sustainable way (United Nations 2015).

In history, the development and deployment of new technology has previously led to conflict due to the profound potential changes they cause within the productive and, consequently, the working and educational structure of societies. With the advancement of automation, machine learning, artificial intelligence, and the creation of cyber-physical systems, where computers and physical systems, mostly applied to production and transportation, integrate, there's likely to be another wave of change that will deeply affect the work structure and transform the skills and qualifications needed to prosper. Mostly affected will be those at the bottom of the pyramid and in regions of difficult access to education. As machines consistently replace repetitive and low qualified jobs, people in developing countries, where most of these jobs are, and workers that lack access to proper education

may be left out of this transformation, which will in turn increase inequality and cause social conflict (Fiorelli 2018).

To sum up, technological innovation has sprung welfare by multiplying economic productivity manifold, helped create products and services that made peoples life's easier, and helped made social progress over decades a reality by deeply transforming the way we live, interact, and make use of our time. However, when it comes to the future sustainability of this progress, many challenges will have to be both internationally and nationally addressed to avoid social unrest and setbacks caused by anti-ethical or unequal exploitation of technological progress.

Environment and Technological Innovation

As seen in the topic above, technological innovation, coupled with the advancement of science and new methods of organization, has helped humanity prosper and made significant leaps forward in the twentieth century. This trend continues at an ever-increasing pace in the twenty-first century as well as the full automation of both industrial and agricultural production, and transportation and information processing is becoming a reality, therefore rapidly increasing the overall levels of productivity in many branches of different industries. However, as said in the first paragraphs of this text, no development can be considered sustainable unless it respects the three pillars of sustainability and all its constraints.

The pace at which economic productivity and world population grew in the last century was unprecedented. Despite being able to do more with less with the increases in productive efficiency and transportation, the amount of goods needed to supply the demands of so many people and the amount of energy, both dirty and clean, now needed to power machines, cars, computers, and the household appliances in people's homes are also unprecedented.

To produce all the goods people consume nowadays, companies and governments must explore a growing portion of land for vegetal resources and search and extract new mineral and other unrenewable resource sources. To transform the raw materials, they utilize energy that comes mostly from unrenewable sources and power productive process that generate vast amounts of pollution, especially in productive clusters that concentrate many industries in a small portion of space. After the consumption, much of the production is thrown away inappropriately, causing synthetic materials that take hundreds of years to decompose to end up in nature, the oceans, even when discarded correctly, to turn into unusable materials, therefore requiring a new extraction of virgin materials to fuel new consumption. Once again, it is important to highlight that production process nowadays are much more efficient than in the past and have a much smaller quantity of material and energy losses. That said, the conclusion is that the amount of materials and energy incorporated in the average unit of product is now smaller than in the past. However, the concern is the absolute amount of resources needed to supply the much more complex needs of today's people and produce goods to a population that is unprecedented in human history in terms of size. This absolute number is the one that is increasing and consuming an ever-larger amount of earth's natural resources, which are stationary when put in human time scale.

To provide a figure of these numbers, the EPA (Environmental Protection Agency) of the United States estimates that each American produced in 2013 about 2 kg of trash per day, already subtracting the amount recycled and only accounting for domestic waste and not considering hazardous or other kinds of waste produced by industries, agriculture, hospitals, and the like (EPA 2016). In the energy field, although on the rise, renewable energies account for only 3.2% of the global energy matrix, the other 96.8% being provided by unrenewable sources and most of it, about 65%, from oil and coal, which are some of the dirtiest processes for energy production (BP 2017).

The impacts on the environmental pillar of sustainability present nowadays perhaps the biggest constraint when it comes to sustainable development. Modern patterns of consumption, especially in the developed world, brought great abundance, but also at a great environmental cost. About this point, technological innovation has its role both as hero and villain. Although it had a great part, technology that made possible these

tremendous advancements in consumption and natural resource exploitation also has a pivotal role in solving them and adjusting development so that it fits three pillars of sustainability.

Sustainability in Higher Education

Fulfilling its scientific and forward-thinking role, the academy nowadays aids in providing detailed data, theories, and proposals to address the modern issues of sustainability. As the dangers and limits of todays' industrial activity, economic and distributive logic, and the modern ways of consumption become clearer, the academy has a pivotal role in preparing future generations to address the resulting issues.

This preparation challenge, however, should not be underestimated as it is a multidisciplinary and interdisciplinary task that has to be carefully addressed. Todays' world is largely more interconnected and complex than it was just a few generations ago. To make its students ready for the challenges posed by sustainability, higher education will have to reinvent many of the curricula currently employed in traditional disciplines and add disciplines that originally would not fit into their course design. Essentially, professionals will need to develop a deep understanding of where their activities take place and how they connect to a much broader context and learn how to learn quicker as the world changes at an ever-accelerating pace.

Energy Technological Innovations

Perhaps the most pressing area of pollution generation and fossil fuel usage, the energy sector, is a big branch of industry where technological innovation is already playing a big role in solving sustainability issues. A vital point that must be understood is that the energy sector of an economy comprises both its production and consumption characteristics. Energy comprises processes that vary from its generation in power plants until the fuel that is burned to propel cars, trucks, and freight ships. Considering the 2017 IEA (International Energy Agency) and its "Energy and Air Pollution" report, we can observe that there are six main air pollutants tracked: sulfur dioxide, nitrogen oxides, particulate matter, carbon monoxide, volatile organic compounds, and ammonia. Over 99% of sulfur dioxide and nitrogen oxides, 92% of carbon monoxide, 85% of the particulate matter, and 66% of volatile organic compound emissions come from energy production and consumption. Only in ammonia does energy have a smaller percentage of 3%.

Once again, these emissions come from diverse energy usage branches. Those include power generation from dirty sources such as coal, oil, gas, and waste, fuel usage in the industry and process emissions, fuel usage in transportation, energy and fuel usage in buildings, and oil, coal, and gas extraction, transformation, and transportation (IEA 2016). Despite simple pollution generation, the energy sector also has a pivotal role in greenhouse gas (GHG) emissions, which are gases that cause global warming, a phenomenon that has been raising concerns for the academia and governments for decades. About 50% of GHG emissions come from electricity and heat production, industry and transportation, and in all of these sectors mostly from burning of fossil fuels such as coal, oil, and natural gas (EPA 2010).

To address the above issues on the energy sector, governments, companies, and the academy have been focusing efforts in developing alternative and renewable sources of energy such as biomass, photovoltaic solar energy, thermal solar energy, and wind power most prominently. At a much less advanced state of development, there's also the process of developing close to 100% clean nuclear fusion energy, a promise for the future that has not yet become a reality as the later.

Despite doubts about the capacity of modern types of renewables such as those to gain scale and power entire economies, the development of technology in these areas in the late years has dropped their cost and increased efficiency. In some cases, using energy from renewable sources or even hybrid systems together with fossils fuels can be cheaper than the usage of traditional sources. Also, these kinds of renewables have been gaining market and growing at an accelerated pace, 4.7% a year on average (REN21 2017). As a relatively recent development, the renewable energy transformation is taking place gradually and constantly taking advantage of new developments. In this regard, technological

innovation will play a key role in further increases of these sources. In turn efficiency and reliability, dropping costs of implementation and operation, and developing applications and solutions to maximize power generation in different regions will expand asymmetrically as these sources rely on geographic conditions and those vary from region to region.

Accompanying this promising possible shift in the world energy matrix are the electric transportation recent developments. About this point, there's an important trade-off to be observed. Although combustions engines and the burn of fossil fuels are a great source of pollution, as mentioned in the paragraphs above, a large-scale shift toward electric vehicles would be beneficial only if the power to supply them were to be generated from renewable sources, or at least gradually so, reducing the impact of fossil fuels on the environment.

Industrial Sustainable Technological Innovations

The manufacturing industry, responsible for the physical production of goods is another key area where technological innovations are having and will have a significant role in promoting sustainable development. The technological possibilities across all branches of the industry are immense, and any specific analysis would require detailed explanation that is out of the scope of this entry. Therefore, we briefly highlight three major process steps that are present in every production process, where these innovation possibilities are available; they are inputs, transformation processes, and outputs (Slack et al. 2009).

Regarding inputs, technological innovation possibilities lay on the development of new renewable materials or in the development of products in which it is possible to reutilize waste or previously discarded products as raw materials. Nowadays, much energy and materials are wasted as raw materials such as metals and oil, that take thousands of years to form in the nature and, considering humanity time span, have a finite amount available, are deployed in products that have life spans of years, months, days, and some of them even minutes – such as packed foods. The great majority of product designs nowadays still doesn't consider the reutilization or does not use the finite resource base fact as an input in its costs and return models. Materials and products are designed in the cheaper and not the more sustainable way to feed the massive stream of consumption they need to address.

In transformation processes, or the production of goods itself, technological innovations can be developed to enable cleaner and more efficient processes. Cleaner processes would be those that utilize environmentally correct chemicals, for example, and other inputs that do not harm the environment. These cleaner production technologies must also address the type of emissions and waste generated during the transformation process. On the other hand, efficiency is related to the conversion of raw materials into products. With efficiency increasing technologies industry is constantly able to reduce the amounts of materials lost during production and the amount of energy required to transform them.

Finally, regarding outputs, the logic is like that of inputs. Technological innovations in industry can aid in devising products that can be utilized as raw materials for others further in the production chain. It can also create products that are biodegradable and don't harm the environment if correctly discarded. Outputs are especially important because among them are products that can be environmentally harming themselves during their life span, for example, cars and household appliances. Not only is the physical composition of the product important but also the technologies employed within it for its use. That said, new clean technologies can also be utilized to constantly reduce the impact a product generates during its life cycle in the same way, reducing emissions, energy consume, material input, waste production, toxic and unrenewable materials utilization, and so forth.

A strong example of this logic is the textile industry. In this industry, consumers nowadays demand products in extremely fast cycles, which means they rapidly become obsolete and are sometimes discarded. According to (Niinimäki and Hassi 2011), the waste from this industry was the fastest growth waste stream in Britain during the years 2005–2010. To solve this problem, technological innovations in recycling the use of sustainable materials and cleaner production processes are solutions

currently in sight. Nevertheless, this industry is also an example where demand-side (consumer-related) solutions are also needed. The short life cycles of this industry result in a large volume of raw materials consumption, industrial processing needed, and waste generated, potentially creating unsustainable patterns of consumption.

As a last remark, recent ICT developments are also now greatly aiding industry in creating a greener supply chain management and regulatory agencies in attributing responsibility to manufacturers, which facilitates environmental law enforcement. With them, it is now much easier to track and identify products sources, more efficiently managing warehouses and minimizing the amount of inventory and unnecessary transportation and creating reverse logistic systems – the collection of a product for reuse by its own manufacturer.

Agriculture Technological Innovations

Apart from its economic and social impact, agriculture is also a fundamental area to consider for the development of technological innovations for sustainability in the environmental pillar. Currently, about a quarter of all the GHG world emissions come from land use-related activities – which include mainly deforestation and agriculture – and both can be correlated (EPA 2010). Apart from that, in the last World Bank assessment, about 37% of the world land area was being utilized for agriculture activities. It is therefore also a major area to be considered when treating global environmental sustainability (World Bank 2015).

Advances in agricultural technology for sustainability include mostly biotechnology, ICT employment, and machinery. It is expected that as technology advances, the amount of raw materials and agricultural inputs wasted can be reduced and used more sustainably by smarter systems of irrigation, genetic engineering, weather forecasting, fertilization, soil study, and harvesting. Technology also has a role in making it possible to develop more sustainable ways of processing and providing energy and fertilization needed without so much reliance on fossil fuels as it is currently observable.

With the massive use of fertilizers in the modern industrial scale agriculture, when looking at a sustainability perspective, it becomes important those methods of fertilization that reduce soil exhaustion and toxic waste disposal. Also, with the amount of production now required from agriculture, it is growingly important the development of new technologies that employ renewable resources in production inputs.

Regarding machinery and ICT advancements, the two are closely intertwined. With ICT progress, it has become increasingly possible to automate the production in the field. Although there is a trade-off since this automation eliminates low qualification jobs from agriculture and harms low productivity farms, it greatly speeds up farm processes such as seeding and harvesting and therefore increases productivity. Moreover, new ICT developments allow the deployment of monitoring and more efficient irrigation systems that facilitate crops in weather forecasting and in rapidly detecting environmental changes in the soil, air, water, and other environmental factors that affect and are affected by agricultural activity.

Final Considerations

Considering the many applications for technological innovation and the challenge of preparing the next generation toward promoting and enabling sustainable development observed in this entry, it is possible to conclude that the development of technological innovation, specifically those that directly aim to contribute to the sustainability goals, has been and still is a powerful way of advancing sustainable development in its three major pillars, the economic, social, and environmental.

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Technology Enhanced Learning

▶ E-Learning and Sustainable Development

Technology Integrated Learning

▶ Technology-Enhanced Learning and Education for Sustainable Development

Technology-Enabled Learning

▶ Technology-Enhanced Learning and Education for Sustainable Development

Technology-Enhanced Learning and Education for Sustainable Development

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Synonyms

Computer-based learning; Educational technology; ESD (education for sustainable development) e-Learning; ICT (information and communications technology); Technology-enabled learning; Technology integrated learning; TEL (technology-enhanced learning); Online learning

Introduction

UNESCO, the United Nations agency for education, states that Education for Sustainable Development (ESD) "aims at developing competencies that empower individuals to reflect on their own actions, taking into account their current and future social, cultural, economic and environmental impacts, from a local and a global perspective" (UNESCO 2017). The term technology-enhanced learning (TEL), synonymous with e-learning, has come to reflect the wide range of possibilities of using technology as both a mode of instruction as well as a means to improve or transform learning that is sustainable. The juxtaposition of these two terms invites consideration of the role of technology in the reimagining of education for sustainable development. This entry will take a deeper look at what is known about both technology-enhanced learning and education for sustainable development, as well as describing both the work that has already been done jointly between these two fields and the challenges inherent in such work related to sustainability. As stated in the forward of UNESCO's Sustainable Development Goals – Learning Objectives document:

> Education is both a goal in itself and a means for attaining all the other SDGs. It is not only an integral part of sustainable development, but also a key enabler for it. That is why education represents an essential strategy in the pursuit of the SDGs. (UNESCO 2017)

An oft-repeated warning on the topic of technology is the ease with which it can slide into the driver's seat in a variety of scenarios. W. Brian Arthur states that technology has a way of engendering its own creation or evolution, and this can be seen in many instances (Arthur 2009). This alluring ability of technology to put itself first exists at all levels of planning and application in an organization. Often the existence of a new piece of technology inspires people and organizations to seek out means for its use; implementation decisions are frequently technology-led rather than being focused on clearly defined educational goals (Goodman 2001; Kirkwood 2014).

The concept of Education for Sustainable Development allows our society to begin the necessary process of recognizing technology-enhanced learning as a tool and using its power to advance sustainability aims. In his book, *Ecological literacy: Education and the Transition to a Postmodern World*, seminal author of ecological literacy David Orr predicts that "economic and technological choices will, in the main, reflect the distribution of power in society" (Orr 1991, p. 66). Complementary to Orr's thinking, leading sustainability expert Stephen Sterling states that "ideas of 'the knowledge society', 'the information economy' and 'the information society' hide questions about sorts of knowledge, controlled by who, for whom, and for what purposes" (Sterling 2001, The Modern-Post Modern Transition, para. 2). The intertwining of the concepts of technology-enhanced learning and education for sustainable development proposes a possible answer to David Orr's question, "What kind of technology, at what scale, and for what purposes" (Orr 1991, p. 37)?

Technology-Enhanced Learning: "The How"

Design

While any technology based attempt at education could potentially be labeled TEL, true technology-enhanced learning involves consideration of the *learning process* and tasks before technology when designing learning environments. In today's world, life is spent in a stream of competing stimuli; attention is a scarcity. According to Goodman, the ultimate question of design within information systems is what information should be selected, as opposed to simply distributing more information (Goodman 2001). Adrian Kirkwood argues against allowing "technological determinism" to dictate terms and reasserts that educators, particularly in higher education, must resist this pull and instead make informed choices about when and how to employ the use of technology in order to enhance learning (Kirkwood 2014). Just as a book can be used for different purposes, such as reference, entertainment, and persuasion, Kirkwood argues that technology artifacts such as blogs, wikis, and more can also be used for different purposes (2014).

Dimensions of Enhancement

Particularly because the phrase technology-enhanced learning can be used so broadly, it is important to consider exactly what the parameters of enhancement are and to what extent they can be defined. In a literature review of many such iterations within the field of higher education, Adrian Kirkwood and Linda Price sought to define both the types of enhancement and how its effects can be measured. They identified the following three types of enhancement:

1. Efficiency: existing processes carried out in a more cost-effective, time-effective, sustainable, or scalable manner
2. Enhancement: improving existing processes and the outcomes
3. Transformation: radical, positive change in existing processes or introducing new processes (Kirkwood and Price 2014)

However, these enhancements do not arise without the necessary groundwork being laid to make intelligent use of the possibilities technology provides. Kirkwood and Price also identified the following ways that studies in their literature review had measured the performance levels of technology-enhanced learning. These categories of measurements include:

1. Operational improvements (such as greater flexibility or more accessible resources)
2. Quantitative changes in learning (exemplars include increased engagement and improved scores)
3. Qualitative changes (such as reflection, deep engagement, and richer understanding) (Kirkwood and Price 2014).

When compared to the parameters of TEL (efficiency, enhancement, and transformation), these quantitative changes are adequate for determining an increase in efficiency, and the operational improvements can be interpreted to measure enhancement, while qualitative changes are indicative of the transformative level of change.

Barriers

Gregory and Lodge identify several potential barriers to the use of technology-enhanced learning in higher education (2015). Initially, they point to the lack of clarity in the definition of technology-enhanced learning and how it has expanded to include learning management systems, distance education, blended learning, online learning, and more. They argue that this confusion, paired with the rapid growth of technology used to support learning, has resulted in a lack of understanding overall, with standards of application that vary by situation and context. Furthermore, Gregory and Lodge posit that while other authors have identified barriers such as time, culture, readiness, and training, there has been a failure to account for what they consider to be a hidden, "silent" barrier – academic workload allocation. They point to the fact that changing toward use of technology often involves a greater allocation of workload initially, and if universities fail to recognize this need, it will continue to hinder the ability of faculty and staff to implement these programs. This concern links back to the potential pitfall of allowing technology to dictate terms rather than identifying how technology can "enhance" learning and what is required for implementation. Gregory and Lodge state that infusing technology-enhanced learning into higher education "should be a transformative process, not merely a cut and paste from traditional models" (Gregory and Lodge 2015, p. 225).

Barriers to effective technology-enhanced learning are not only at the level of the perspective of the university and its professors but also at the student perspective. Kennedy et al. argued that the assumption that all young adults are technologically savvy and competent must also be examined, which is critical to designing adequate technology-enhanced learning (Kennedy et al. 2008). While today's young adults may have grown up using technology for recreation, they may still lack skills for its critical use in the context of higher education; these prerequisite skills cannot be taken for granted.

Access

An additional issue to consider in the use of technology-enhanced learning toward education for sustainable development from the student

point of view is development with an eye toward ensuring access. This can include access for people with disabilities, through the use of universal design for learning (UDL) in instructional design. Stuart Peter Dinsmore named several complementary features of UDL and TEL:

1. Have the concept of flexibility at their core
2. Rely on a technology-rich environment with groups of networked learners
3. Encourage self-paced learning through the provision of Internet-based materials
4. Rely on a high level of explicit communication with students partly facilitated by ICT
5. Both are focused on the creation of lifelong or expert learners (2014).

Decisions

Technology-enhanced learning ultimately begins when leaders create a vision and strategy for the role of technology within their learning environments and institution, followed by a description of how and what they want people to learn using technology. The decision of which technologies can meet these ends is considered only after these initial considerations have been met. These decisions involve consideration of UDL, how to account for the additional workload in higher education, and determining whether the goal is efficiency, enhancement, or transformation of learning. Ultimately, organizations responsible for creating and carrying out technology-enhanced learning must ask themselves several questions, such as:

1. In what contexts is learning available with technology?
2. Is technology-enhanced learning making a difference?
3. If so, what kind of a difference? Qualitative, quantitative, or transformative?

Education for Sustainable Development: The "Why"

Sustainable Development Goals

Technology-enhanced learning is best derived by planned goals based on learning processes, tasks, and environments. Fortunately, UNESCO has clearly defined 17 Sustainable Development Goals (SDGs) with the modest ambition of transforming the world. These SDGs provide a clearly laid out roadmap for the task at hand; what remains is the determination of how best to deploy the use of technology to serve this end.

Sustainable Development Goal #4 is Quality Education (UNESCO 2017). This goal encompasses the importance of lifelong learning, a free and quality education for all, education as the key to sustainability and peace, and education as empowerment. UNESCO has identified a series of key competencies related to all SDGs, which include system thinking, anticipatory competency, normative competency, strategic competency, collaboration, critical thinking, self-awareness, and integrated problem-solving.

Sustainability Literacy

A case study of education for sustainable development using technology-enhanced learning was shared by Azeiteiro et al. (2014). He and his colleagues used an institute of higher education dedicated primarily to distance-based education in Portugal to examine the attitudes of students learning sustainability literacy principles. Qualitative research confirmed a high level of satisfaction with the experience, indicating that technology-enhanced learning done well has the potential to serve the field of education for sustainable development.

Access

Another dimension of consideration involves people in developing nations. A literature review of technology-enhanced learning in developing nations revealed issues regarding access to and ability to use devices, internet access, and adequate infrastructure (Gulati 2008). Gulati noted that even when infrastructure is built up for developing countries, it may only serve to further widen the gap—the opposite of the intent of education for sustainable development. Along this same vein, implementers must be aware that using technology-enhanced learning toward education for sustainable development has the potential to further entrench existing inequities regarding not only knowledge access in the

present but also regarding who is enabled and empowered to add to digital content in the future.

Responsible Use

In considering the use of technology-enhanced learning toward education for sustainable development, an additional concern is materials and responsible use. In the *Handbook for Sustainability Literacy,* Clifford wrote that "technology is becoming obsolete at an increasing rate: mobile phones are typically replaced by users after 18 months, whereas it takes over 1000 years for a mobile phone to decompose naturally" (Clifford 2009, p. 147). It would be short-sighted to consider the use of technology toward education for sustainable development without planning for responsible use of materials and equipment.

Using Technology-Enhanced Learning to Achieve Education for Sustainable Development

Mobile Solutions

UNESCO has produced a toolkit for using information and communication technology toward for the purpose of education, called the ICT-in-Education Toolkit (Unesco ICT-in-Education Toolkit n.d.). It provides concrete steps toward developing a plan, designing a program, and monitoring its effectiveness and impact. Another potential option includes the seamless learning framework of distributed cognition described by Looi et al. in a study examining the effectiveness of mobile technology in sustainable learning.

> By organizing and sharing information across design experiments in diverse settings, a collaboration of researchers can more rapidly and systematically explore the design space. For instance, the same-grade classrooms across different countries can implement mobile learning devices for all subject areas, allowing a broad examination of solutions and challenges. By collaborating across the globe, researchers could take advantage of different student device preferences, exchange curriculum ideas, understand cultural differences, and better address issues of scale. (Looi et al. 2010, pp. 166–167)

Empowerment

Another example of using technology-enhanced learning for education for sustainable development comes from a framework for using e-learning to support student sustainability literacy (SSL) proposed by Susannah Diamond and Brian Irwin. They identified four pillars of successful SSL:

1. Conceptual awareness of sustainability issues in the real world
2. Personal identity and values aligned with achieving sustainability
3. Competence in skills which can contribute to achieving sustainability
4. Confidence in an ability to contribute to achieving sustainability (Diamond and Irwin 2013).

The authors conducted a literature review and used this framework to analyze the effectiveness of the use of technology to support student sustainability literacy. They found multiple examples of the use of technology for skill development, conceptual development, identity development, and confidence development but noted an imbalance toward transmissive types of instruction verses student-centric or constructivist methods (Diamond and Irwin 2013). They recommended that e-learning be extended further beyond basic skill and concept instruction in order to develop the identity and confidence necessary to empower students to take action.

Regarding this need for empowering young people to take action, Chin and Jacobbsen asserted, "learning is pivotal in connecting global development goals to local realities" (Chin and Jacobbson 2015). They described a program that combines ICT and sustainability literacy called TheGoals.org, which emerged from a distance education program on ESD for high school age population. This platform allows people from all over the world to connect via both a website and smartphone application to learn more about the 17 SDGs and share how they are addressing them. Courses on each SDG are offered, and registrants can enroll for free as students or coaches. The cost incurred per participant is estimated at less than $5.00 per

person, and the application is optimized to run on a range of smartphones, including those that are less expensive.

Affect

Scott Warren and Jenny Wakefield undertook an effort to reach young adults engaged in coursework in higher education (2016). They examined the role of affect in online discussions, seeking to avoid the typical transmissive, acquisition-based nature of education and foster students' ability to engage emotionally and constructively with real problems through "emancipatory discourse" (Warren and Wakefield 2016). Their online course taught the use of several technology-enhanced tools for the purpose of learning about and discussing two of the eight United Nations Millennial Goals: environmental sustainability and combating HIV/AIDS. The authors captured three emergent themes throughout the course:

1. Affect, Emotions, and Awareness Expressions
2. Acceptance (with and without calls to action)
3. Agreement and Questioning

Warren and Wakefield concluded:

> Technology can support multiple forms of emancipation for learners through its ability to connect those over long distances and an associated free sharing of knowledge in online settings. . .through learning about the UNMD goals and related world problems, our students' social awareness of themselves in a world with multifaceted, often stressful societal needs, issues, and power relationships increased and resulted in expression of emotions that contributed to their personal growth. (2016, p. 64)

This study is a prime example of ways in which technology-enhanced tools can be used to further education for sustainable development.

Social Integration

A final example of integrating technology-enhanced learning and education for sustainable development comes from the STELLAR Network of Excellence, (Sustaining Technology-enhanced learning at a LARge scale), a project of the European Union to promote interdisciplinary research from higher education institutions. At a series of conferences and meetings, this network created a list of Grand Challenge Problems to direct future research and collaboration. These 30 TEL Grand Challenge Problems were defined as, "fundamental socio-technical problems whose solution will lead to breakthroughs that improve learning and educational systems and bring long-term benefits to society" (Fischer et al. 2014, Chap. 1, Section 1.1, para. 1). According to STELLAR:

> Learning is intimately connected with social interaction between people and as the continual construction of knowledge. New digital tools connect learners with other learners and teachers, trainers, experts or more knowledgeable others, helping them to communicate in effective ways, both to share and build knowledge. A wide variety of information and communication technologies (ICTs) connect people including web-based applications such as open and closed forums, personal or shared blogs, chat rooms, instant messaging and video conferences, tagging and collaborative text editing systems. (Fischer et al. 2014, Chapter 2, Section 2.1, para. 1)

STELLAR's work followed three themes: connecting learners, orchestrating learners, and contextualizing learning (Fischer et al. 2014). For each of the 30 problems, the series of questions included:

1. What problems of the European education system are addressed, and what are the long- term benefits for society?
2. What are the main activities to address this Grand Challenge Problem?
3. What is the timeframe for the Grand Challenge Problem?
4. What are measurable progress and success indicators?
5. How can funding be attracted?
6. What are connected research questions? (Fischer et al. 2014.

Examples of the problems include:

GCP4: Supporting an Open Culture of Design for TEL
GCP6: Emotion-Adaptive TEL
GCP13: Learning Reading at Home

The GCPs, like the SDGs, provide a solid framework for furthering collaboration and research, as well as an example for other organizations or countries seeking development or adaptation of these or similar problems regarding their own education systems.

Emerging Theories

While there are numerous connections to technology-enhanced learning, several emerging theories include the areas of new media, media ecology, and diffractive technospaces. In *The Handbook of Sustainability Literacy*, Chap. 16, New Media Literacy, John Blewitt writes, "it is necessary to establish a new civil contract between the image, the text, the sound and the senses, determined by the political and pragmatic project of living and learning in our uncertain and risky world" (Blewitt 2009, p. 112). Because our current society is "highly mediated," Blewitt noted that there is little line between consumers and producers of media and that it provides a tool for potential transformation (2009). Media ecology extends the idea of new media and interaction, the concept of mediation, and the emerging, ongoing entanglement between people and media. According to Christine Nystrom, media ecology can be considered an examination of communication systems as though they were environments (Nystrom 1973). Federica Timeto defined *technospaces* as "the sociotechnical environments in which humans and machines relate and intersect" (Timeto 2015, p. 1). She asserted that:

> The relational. . .linkage between spaces and representations. . .pays attention to the ecosystemic interconnections of contemporary technospace. . .In an ecosystemic framework, in which systems are characterized by relational openness and intensive multiplicity rather than self-sufficiency. . . representational practices find themselves entangled in local contaminations, haunted by the pleasure of connection as well as by the always possible danger of disconnection." (Timeto 2015, p. 159, 161)

She argues that in many ways, mediation is what happens at the conjunction of relations and that there is no clear demarcation between two sides or binaries.

Conclusion

The expansive field of technology-enhanced learning represents an excellent array of tools that can be employed in a variety of areas of education, for multiple purposes. Grounding technology-enhanced learning solidly in the co-concept of education for sustainable development lends it a greater purpose and a wider impact. When designing education using TEL, educators face consideration of dimensions of enhancement, barriers, access, and decisions. The field of ESD can be better understood by reviewing UNESCO's 17 Sustainable Development Goals, sustainability literacy, access, and responsible use. Areas of TEL within education for sustainable development include mobile use, technology as empowerment, consideration of affect within technology, and emancipation through technology, social interaction, and emerging areas (such as media ecology and technospaces). While technology-enhanced learning can be employed in unlimited directions, harnessing its power within the context of education for sustainable development provides answers for both why and how technology can serve a strong role within sustainability.

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TED Talks on Environment Issues for Sustainable Development

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Synonyms

Environmental concerns; Environmental problems

Definition

TED talks: TED (Technology, Entertainment and Design) is a non-profit organization that was born in 1984.

Environmental Issues: Several environmental issues such as: Pollution; climate change and global warming; overpopulation; natural resource depletion; waste production and disposal; loss of biodiversity; deforestation; ocean acidification; urban sprawl; genetic engineering or genetics modification of food; species extinction.

Sustainable development: "Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987, p.16).

Introduction

The planet has been suffering from several environmental issues such as pollution, climate change and global warming, overpopulation, natural resource depletion, waste production and disposal, loss of biodiversity, deforestation, ocean acidification, urban sprawl, genetic

engineering or genetics modification of food, and species extinction (Gardner and Stern 2005; Vlek and Steg 2007). Questions related to environmental problems have drawn the attention of several researchers, global organizations, universities, public and private companies, the media, teachers, lecturers, professors, businessmen, students and consumers, due to the concern on environmental issues and how we can achieve sustainable development.

For example, the UN has proposed 17 sustainable development goals to be implemented by 2030, among which we highlight are the following: No Poverty; Zero Hunger; Good Health and Well-Being; Quality Education; Gender Equality; Clean Water and Sanitation; Affordable and Clean Energy, Decent Work and Economic Growth; Industry, Innovation and Infrastructure; Reduced Inequalities; Sustainable Cities and Communities; Responsible Consumption and Production; Climate Action; Life Below Water; Life and Land; Peace, Justice and Strong Institutions; and Partnerships for the Goals (UNDP 2016).

But what is sustainable development? This concept became popular through the publication of the Brundtland report in 1987, being defined as: "Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987, p. 16). For Elkington (1994), sustainable development must take into account three aspects of development: economic, social, and environmental.

Therefore, we verify the importance of these themes, of environmental issues and of sustainable development worldwide. We can highlight that new initiatives and tools are being created and can help in the awareness and diffusion of environmental issues, by proposing solutions or presenting innovative ideas for these problems. In this study, we will highlight the TED's performance through their videos known as TED Talks. We emphasize that in the literature, we have not yet identified scientific articles dealing with the issue of TED Talks videos in relation to environmental problems for sustainable development.

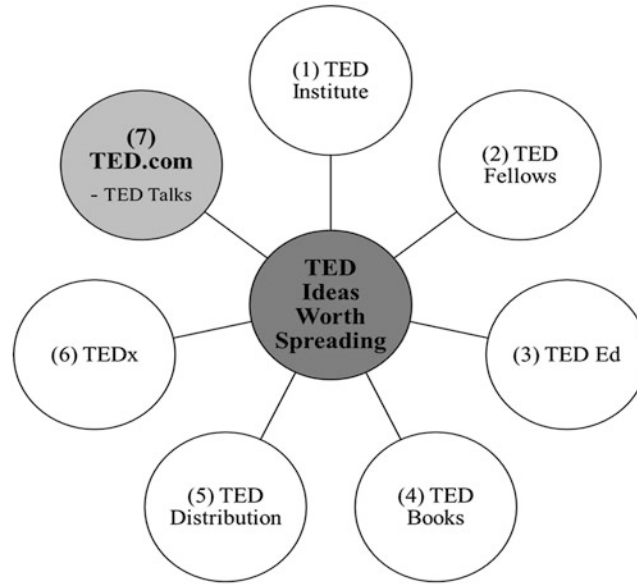
TED (Technology, Entertainment, and Design) and TED Talks

TED (Technology, Entertainment, and Design) is a nonprofit organization that was born in 1984 and covers a conference network in more than 130 countries (Stob 2015). It is currently considered one of the largest internet providers (Pappas and Popescu-Belis 2015) which has a large number of lectures delivered by scientists, philosophers, musicians, businessmen, and religious leaders (Hu and Li 2017) and may even contain presentations by some of the world's leading academics, animators, intellectuals, politicians, and entrepreneurs (Stob 2015).

TED has a variety of projects and initiatives, such as the following: (1) TED Institute, (2) TED Fellows, (3) TED-Ed, (4) TED Books, (5) TED Distribution, (6) TEDx, and (7) TED.com. There is on TED.com; we highlight TED Talk, it will be the TED initiative being analyzed in this study, as can be seen in Fig. 1.

TED Talks are short videos, with free and educational access posted on the internet (Scotto di Carlo 2014; Romanelli et al. 2014). TED Talks seek to present in no longer than 18 min an innovative idea that presents a problem while concurrently seeking to offer a solution to this problem (DaVia Rubenstein 2012). It is considered as the most popular conference and events website (Sugimoto et al. 2013; Romanelli et al. 2014). TED Talks are translated by more than 15,000 volunteers (Taibi et al. 2015) to the most diverse languages.

Romanelli et al. (2014) highlighted that TED Talks videos are structured, follow a specific format, are persuasive, and highlight the speaker's passion for the theme. Moreover, Romanelli et al. (2014) compared the essential aspects of TED Talks in relation to academic articles on subject, goals, timeframe, style, assessment, mode speaker, context, audience, structure, visuals, and preparation.



TED Talks on Environment Issues for Sustainable Development, Fig. 1 Programs and initiatives. (Source: https://www.ted.com/about/programs-initiatives)

Another item that highlights TED Talks is its focus on creating a presentation full of advice, sharing real problems and solutions, and can thus be considered a powerful tool that encourages action, on how the power of speech can contribute to changing the world (Scotto di Carlo 2014; Hayward 2017). Furthermore, according to Caliendo (2012), TED Talks videos present their lectures using accessible language to disseminate scientific knowledge to diverse nonspecialized audiences.

We verified that some authors, such as Loya and Klemm (2016), reinforced that TED Talks offer educators the opportunity to take to the classroom, and free of charge to their students, relevant information from experts from various areas. On the other hand, according to Romanelli et al. (2014), we can verify that approaches by TED Talks also have their critics, who argue that TED Talks videos use a preconceived format primarily for entertainment.

TED Talks have spread over the Internet to great dimensions, for example, currently having more than billion online views, and is considered as a phenomenon of scientific communication (Sugimoto et al. 2013; Tsou et al. 2014). Thus, these TED Talks videos can be used as a tool to disseminate information and research on various topics, among them, those related to environmental issues faced by the world. Thus, due to the size, reach, and success of TED Talks, these can be used as a tool to raise awareness and propagate actions to minimize environmental issues and to raise awareness of the importance of sustainable development. We will discuss this in the next topic.

What Do "TED Talks" Videos Show About Environmental Issues for Sustainable Development?

As we have discussed in previous topics, TED Talks videos, as well as famous and with billions of views, can be used by researchers to disseminate their research, to talk about their passions, and finally to present their ideas on a particular topic. Therefore, we performed a search on the website (https://www.ted.com/talks) on December 1, 2017, and we were able to verify 2642 videos currently on the website, and new videos are added constantly. TED Talks videos can be selected on the website from the filters shown in Table 1.

To select TED Talks on environmental issues, we first accessed the website https://www.ted.

TED Talks on Environment Issues for Sustainable Development, Table 1 TED talks filters

Search filter	Description
Search talks	In this item, we have the option of entering a keyword to search
Topics	In the item topics, we have the option to select A–Z keywords; there are currently 429 topics. The most popular ones being "Technology, Entertainment, Design, Business, Science and Global Issues"
Languages	There are more than 120 languages in which we can watch the videos. Transcripts and subtitles are available in more than 100 languages
Duration	With most videos usually being of up to 18 min. We can select videos by duration of 0–6 min, 6–12 min, 12–18 min, and 18+ min
Events	One can find videos of different events like TED conference, TEDGlobal, TEDx, etc.
Find a speaker	We can choose to select a specific speaker
Sort by	This is another filter that can be used, such as "newest, oldest, Most viewed, jaw-dropping, funny, persuasive, courageous, ingenious, fascinating, inspiring, beautiful, and informative"

Prepared by the authors
Source: https://www.ted.com/talks

com/talks, and then we performed a topic search and read the titles and then the synopses, and finally, we selected and analyzed 99 videos that deal with the most diverse environmental issues faced in the world. This selection process is shown in Fig. 2.

We could verify that of the 99 videos that deal with different environmental problems, 32% refer to climatic changes, as shown in Table 2.

From Table 3, we can verify that the year 2017 was the year that had the most published videos related to environmental problems and the videos of the year 2016 were the ones that had the highest number of views (18,610,510). In total, the 99 TED Talks were viewed by approximately 113,824,897 individuals; this reinforces the impact and comprehensiveness of these videos and their importance in publicizing environmental problems facing the world and the possible solutions proposed.

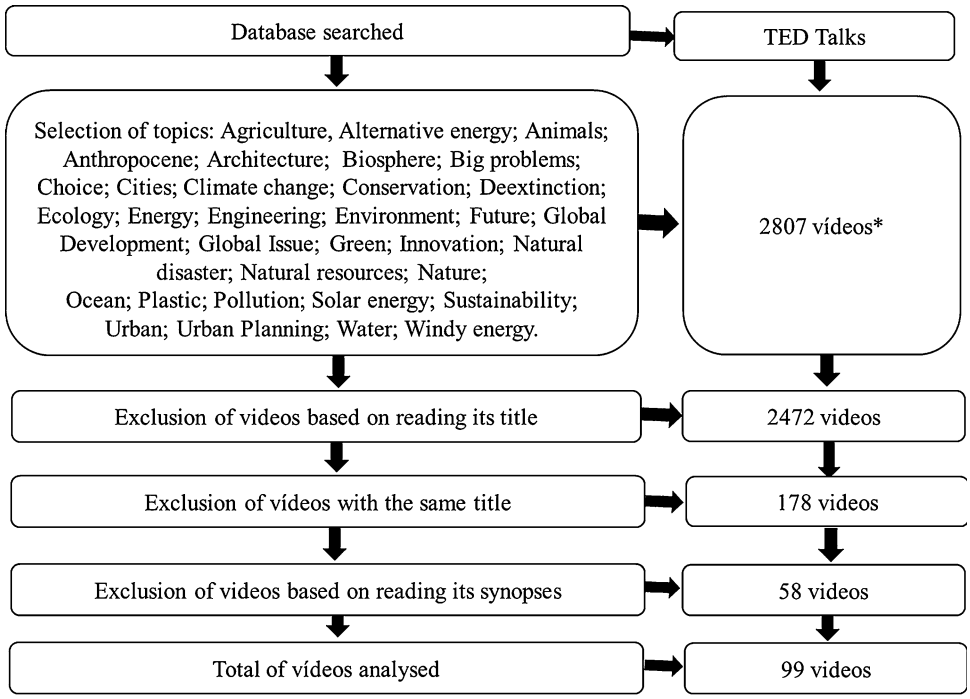
In Table 4, we present the 99 TED Talks about environmental problems, their respective video title, speakers, speaker's country of work, speaker's main profession, year of video, and views. We emphasize that the majority of the speakers are from the USA, with 54 videos. The two videos with the most views were on climate change: the first one by Allan Savory (video title: How to fight desertification and reverse climate change) with 4,354,724 views and the second one by Al Gore (video title: Averting the climate crisis) with 3,225,088 views.

Conclusions, Suggestions for Future Research, and Limitations

As for the environmental problems mostly discussed by TED Talks, we identified 99 videos that deal with environmental problems, with a total of 113,824,897 views, and the climate change theme with the largest number of published videos. Therefore, TED Talks can play an important role in disseminating and raising awareness of environmental problems and in presenting possible solutions to these problems and can contribute to the planet achieving sustainable development.

As for the suggestion of future research, a cluster analysis can be performed from the topics; another suggestion is the accomplishment of a more exploratory research with the analysis of the transcriptions of the lectures and on the main environmental problems mentioned by the TED Talks videos and the main proposed solutions to these problems.

As for the limitation of this research, we can mention that there may be other videos that deal with environmental problems for sustainable development and that may not have been inserted in this research. Because the video selection process by "topics" still has its limitations, this has already been mentioned by Hu and Li (2017). Currently, the videos are indexed on the TED website, and the search process can be performed by "search talks," "topics,"



TED Talks on Environment Issues for Sustainable Development, Fig. 2 "Selection Process", need Fig. 2 Videos' selection process. Source: Prepared by the authors; *2807 videos were identified because some topics include the same videos

TED Talks on Environment Issues for Sustainable Development, Table 2 Environmental issues and videos

Environmental issues	Videos	%
Climate change	32	32%
Pollution	24	24%
Natural resource depletion	22	22%
Species extinction	6	6%
Deforestation	5	5%
Overpopulation	4	4%
Global warming	3	3%
Loss of biodiversity	1	1%
Urban sprawl	1	1%
Waste production and disposal	1	1%
Total	99	100%

Source: Prepared by the authors

TED Talks on Environment Issues for Sustainable Development, Table 3 Year, number of videos, and views

Year	Number of videos	Views
2017	16	16,379,448
2016	15	18,610,506
2015	7	8,920,747
2014	5	4,443,862
2013	10	15,287,228
2012	13	14,709,050
2011	1	990,695
2010	15	13,512,668
2009	10	10,798,187
2008	1	1,793,750
2007	2	2,563,483
2006	2	3,829,911
2005	2	1,985,362
Total	99	113,824,897

Source: Prepared by the authors

"languages," and "duration" (https://www.ted.com/topics). However, these filters do not tend to be sufficient for the selection process of the videos and to debate about a particular theme, for example, environmental issues and sustainable development. It could be of true value, if the TED Talks website included more specific keywords, just as it is done for scientific articles; this could contribute to an improvement in the process of search and selection of videos by theme.

TED Talks on Environment Issues for Sustainable Development, Table 4 Environmental issue on TED talks

N	Environmental issue	Video title	Speaker	Speaker's country of work	Speaker's main profession	Year of video	Views
1	Climate change	A climate solution where all sides can win	Ted Halstead	USA	Founder and CEO of the Climate Leadership Council	2017	1,130,308
2	Climate change	A critical look at geoengineering against climate change	David Keith	Canada	Professor at the University of Calgary	2007	927,346
3	Climate change	A provocative way to finance the fight against climate change	Michael Metcalfe	USA	Work at State Street Global markets	2016	1,198,708
4	Climate change	Can clouds buy us more time to solve climate change?	Kate Marvel	USA	Scientist at Columbia University	2017	1,077,059
5	Climate change	Can we stop climate change by removing CO2 from the air?	Tim Kruger	United Kingdom	Professor at University of Oxford	2017	899,450
6	Climate change	Discovering ancient climates in oceans and ice	Rob Dunbar	USA	Professor at Stanford University	2010	555,035
7	Climate change	Global priorities bigger than climate change	Bjorn Lomborg	Denmark	President of the Copenhagen Consensus center and visiting Professor at Copenhagen Business School	2005	1,411,258
8	Climate change	Global warming's theme song, "Manhattan in January"	Jill Sobule	USA	Singer	2006	604,823
9	Climate change	How the military fights climate change	David Titley	USA	Professor at Pennsylvania State University	2017	706,860
10	Climate change	Let the environment guide our development	Johan Rockstrom	Sweden	Professor at Stockholm University	2010	955,846
11	Climate change	Let's prepare for our new climate	Vicki Arroyo	USA	Executive Director of the Georgetown Climate Center	2012	1,043,801
12	Climate change	My country will be underwater soon – unless we work together	Anote Tong	Kiribati	He was President of the Republic of Kiribati	2015	1,067,297
13	Climate change	New thinking on the climate crisis	Al Gore	USA	45th Vice President of the United States	2008	1,793,750
14	Climate change	The emergent patterns of climate change	Gavin Schmidt	USA	Scientist at Columbia Universty's Earth Institute	2014	1,164,614
15	Climate change	The ocean's shifting baseline	Daniel Pauly	Canada	Researcher at University of British Columbia	2010	228,662
16	Climate change	The science behind a climate headline	Rachel Pike	Canada	Researcher at the University of Cambridge	2009	477,140

(*continued*)

TED Talks on Environment Issues for Sustainable Development, Table 4 (continued)

N	Environmental issue	Video title	Speaker	Speaker's country of work	Speaker's main profession	Year of video	Views
17	Climate change	The state of the climate – and what we might do about it	Nicholas Stern	United Kingdom	President of the British Academy	2014	782,945
18	Climate change	We need nuclear power to solve climate change	Joe Lassiter	USA	Professor at Harvard Business School	2016	1,090,578
19	Climate change	What's hidden under the Greenland ice sheet?	Kristin Poinar	USA	Professor at University at Buffalo	2017	1,165,174
20	Climate change	Why climate change is a threat to human rights	Mary Robinson	Ireland	She was president of Ireland	2012	1,152,201
21	Climate change	Why I must speak out about climate change	James Hansen	USA	Professor at Columbia University's Earth Institute	2012	1,269,676
22	Climate change	A 40-year plan for energy	Amory Lovins	USA	Chief Scientist Rocky Mountain Institute	2012	1,162,059
23	Climate change	A reality check on renewables	David MacKay	United Kingdom	Professor at University of Cambridge	2012	471,567
24	Climate change	A small country with big ideas to get rid of fossil fuels	Monica Araya	Costa Rica	Advocate, communicator and adviser	2016	1,056,988
25	Climate change	Averting the climate crisis	Al Gore	USA	45th vice president of the United States	2006	3,225,088
26	Climate change	Climate change is happening. Here's how we adapt	Alice Bows-Larkin	United Kingdom	Researcher at University of Manchester	2015	1,175,124
27	Climate change	Debate: Does the world need nuclear energy?	Stewart Brand and Mark Z. Jacobson	USA	Environmentalist and futurist (Stewart Brand) Professor at Stanford University (Mark Z. Jacobson)	2010	1,323,385
28	Climate change	How to fight desertification and reverse climate change	Allan Savory	USA	President and co-founder of the Savory Institute	2013	4,354,724
29	Climate change	Ted Halstead A climate solution where all sides can win	Ted Halstead	USA	Founder and CEO of the Climate Leadership Council	2017	1,130,843
30	Climate change	The case for optimism on climate change	Al Gore	USA	45th Vice President of the United States	2016	1,663,995
31	Climate change	The inside story of the Paris climate agreement	Christiana Figueres	Costa Rica	Former executive secretary of the UN Framework Convention on Climate Change (UNFCCC)	2016	1,053,837
32	Climate change	What rivers can tell us about the Earth's history	Liz Hajek	USA	Assistant Professor at Pennsylvania State University	2017	1,225,041

33	Climate change	Why we need to imagine different futures	Anab Jain	United Kingdom	Co-founder and Director of Superflux	2017	1,438,585
34	Deforestation	A drone's eye view of conservation	Vicki Arroyo	USA	Executive Director of the Georgetown Climate Center	2013	605,315
35	Deforestation	Ecology from the air	Greg Asner	USA	Researcher Carnegie Institution for Science	2013	703,690
36	Deforestation	Save rainforests hopeful lessons from the battle to	Tasso Azevedo	Brazil	Forestry and climate change consultant and social entrepreneur	2014	887,860
37	Deforestation	How to grow a forest in your backyard	Shubhendu Sharma	India	Eco-entrepreneur	2016	1,382,399
38	Deforestation	The magic of the Amazon: a river that flows invisibly all around us	Antonio Donato Nobre	Brazil	Researcher	2010	1,007,618
39	Global warming	How to transform apocalypse fatigue into action on global warming	Per Espen Stoknes	Norway	Psychologist	2017	782,799
40	Global warming	Why I still have hope for coral reefs	Kristen Marhaver	USA	Marine biologist	2017	1,134,842
41	Loss of biodiversity	The case for fish farming	Mike Velings	Netherlands	Founder A-Spark Good Ventures	2015	1,198,222
42	Loss of biodiversity	How do you save a shark you know nothing about?	Simon Berrow	Ireland	Marine biologist	2010	484,720
43	Natural resource depletion	Four ways we can avoid a catastrophic drought	David Sedlak	USA	Professor at University of California	2016	1,026,625
44	Natural resource depletion	A bath without water	Ludwick Marishane	South Africa	Entrepreneur, Inventor Drybath	2012	1,608,554
45	Natural resource depletion	A clean energy proposal – race to the top!	Jennifer Granholm	USA	Canadian-American politician	2013	750,082
46	Natural resource depletion	Abundance is our future	Peter Diamandis	USA	Entrepreneur	2012	1,389,288
47	Natural resource depletion	Don't build your home, grow it!	Mitchell Joachim	USA	Co-president at Terreform ONE	2010	1,362,164

(*continued*)

TED Talks on Environment Issues for Sustainable Development, Table 4 (continued)

N	Environmental issue	Video title	Speaker	Speaker's country of work	Speaker's main profession	Year of video	Views
48	Natural resource depletion	Fusion is energy's future	Steven Cowley	United Kingdom	Director of the Culham Fusion Science Center	2009	713,630
49	Global warming	How fear of nuclear power is hurting the environment	Michael Shellenberger	USA	Climate policy expert	2016	1,221,619
50	Natural resource depletion	How I brought a river, and my city, back to life	Aziza Chaouni	Canada	Teacher at University of Toronto	2014	677,714
51	Natural resource depletion	How to keep rivers and streams flowing	Rob Harmon	USA	Natural resources expert	2010	602,993
52	Natural resource depletion	How we can make crops survive without water	Jill Farrant	South Africa	Professor at University of Cape Town	2015	1,355,076
53	Natural resource depletion	How we can make the world a better place by 2030	Michael Green	USA	Social progress expert	2015	1,197,216
54	Natural resource depletion	My wish: Protect our oceans	Sylvia Earle	USA	Oceanographer	2009	1,171,892
55	Natural resource depletion	Nature is everywhere – we just need to learn to see it	Emma Marris	USA	Nonfiction writer	2016	1,036,883
56	Natural resource depletion	The ancient ingenuity of water harvesting	Anupam Mishra	India	Environmentalist	2009	844,775
57	Natural resource depletion	This country isn't just carbon neutral – it's carbon negative	Tshering Tobgay	Bhutan	Prime Minister of Bhutan	2016	2,033,313
58	Natural resource depletion	Transition to a world without oil	Rob Hopkins	United Kingdom	Independent activist and writer on environmental issues	2009	816,615

59	Natural resource depletion	A country with no water	Fahad Al-Attiya	Qatar	Food security expert	2012	1,427,337
60	Natural resource depletion	A young scientist's quest for clean water	Deepika Kurup	USA	Inventor and Student scientist	2016	1,002,630
61	Natural resource depletion	High-altitude wind energy from kites!	Saul Griffith	Australian	Inventor	2009	640,368
62	Natural resource depletion	How I built a windmill	William Kamkwamba	Malawi	Inventor	2007	1,636,137
63	Natural resource depletion	How I teach kids to love science	Cesar Harada	United Kingdom	Teacher at Goldsmiths University London	2015	1,657,350
64	Natural resource depletion	Let the environment guide our development	Johan Rockstrom	Sweden	Professor at Stockholm University	2010	955,832
65	Natural resource depletion	Let's transform energy – with natural gas	T. Boone Pickens	USA	Entrepreneur and energy theorist	2012	619,100
66	Natural resource depletion	The missing link to renewable energy	Donald Sadoway	USA	Materials engineer	2012	1,825,020
67	Overpopulation	How megacities are changing the map of the world	Parag Khanna	Singapore	Global Strategist	2016	945,590
68	Overpopulation	The earth is full	Paul Gilding	USA	Writer, environmentalist, consultant	2012	1,188,742
69	Overpopulation	Wiring an interactive ocean	John Delaney	USA	Oceanographer	2010	334,277
70	Overpopulation	Global population growth, box by box	Hans Rosling	Sweden	Global health expert; data visionary and Professor at Sweden's Karolinska Institute	2010	3,021,406
71	Pollution	4 environmental "heresies"	Stewart Brand	USA	Environmentalist and futurist	2009	656,225
72	Pollution	7 principles for building better cities	Peter Calthorpe	USA	Urban designer	2017	1,162,786
73	Pollution	A novel idea for cleaning up oil spills	Cesar Harada	United Kingdom	Teaches at Goldsmiths University London	2012	848,964
74	Pollution	A robot that eats pollution	Jonathan Rossiter	United Kingdom	Professor of Robotics at University of Bristol	2017	1,158,343

(*continued*)

TED Talks on Environment Issues for Sustainable Development, Table 4 (continued)

N	Environmental issue	Video title	Speaker	Speaker's country of work	Speaker's main profession	Year of video	Views
75	Pollution	A smog vacuum cleaner and other magical city designs	Daan Roosegaarde	Netherlands	Dutch artist and founder of Studio Roosegaarde	2017	882,231
76	Pollution	A young inventor's plan to recycle styrofoam	Ashton Cofer	USA	Inventor	2017	1,119,260
77	Pollution	Are mushrooms the new plastic?	Eben Bayer	USA	CEO and co-founder Ecovative	2010	1,112,329
78	Pollution	Fashion has a pollution problem – can biology fix it?	Natsai Audrey Chieza	United Kingdom	Design research	2017	654,893
79	Pollution	How human noise affects ocean habitats	Kate Stafford	USA	Professor at University of Washington in Seattle	2016	1,078,762
80	Pollution	How pollution is changing the ocean's chemistry	Triona McGrath	Ireland	Chemical oceanographer	2016	1,192,616
81	Pollution	Our campaign to ban plastic bags in Bali	Melati and Isabel Wijsen	Indonesia	Speakers	2015	1,270,463
82	Pollution	Paper beats plastic? How to rethink environmental folklore	Harish Manwani	No identified	COO, Unilever	2013	1,242,958
83	Pollution	Planning for the end of oil	Richard Sears	USA	Visiting scientist at MIT	2010	609,305
84	Pollution	Sanitation is a basic human right	Francis de los Reyes	USA	Professor at North Carolina State University	2013	759,218
85	Pollution	Save the oceans, feed the world!	Jackie Savitz	USA	Vice President for U.S. Oceans	2013	1,192,495
86	Pollution	Seas of plastic	Charles Moore	USA	Founder of the Algalita Marine Research Foundation	2009	1,121,023
87	Pollution	The economic injustice of plastic	Van Jones	USA	Social justice and green energy activist	2010	480,513

88	Pollution	Two young scientists break down plastics with bacteria	Miranda Wang and Jeanny Yao	USA	Science fair winners	2013	1,234,250
89	Pollution	Uber's plan to get more people into fewer cars	Travis Kalanick	USA	Entrepreneur	2016	1,625,963
90	Pollution	A new ecosystem for electric cars	Shai Agassi	Israel	Entrepreneur	2009	1,151,309
91	Pollution	How to grow fresh air	Kamal Meattle	Indian	Entrepreneur	2009	3,205,210
92	Pollution	The future of cars	Larry Burns	USA	Automotive researcher	2005	574,104
93	Pollution	Tough truths about plastic pollution	Dianna Cohen	USA	Artist and co-founder of the plastic pollution coalition	2010	707,245
94	Species extinction	The dawn of de-extinction. Are you ready?	Stewart Brand	USA	Environmentalist and futurist	2013	1,955,266
95	Species extinction	Every city needs healthy honey bees	Noah Wilson-Rich	USA	Entrepreneur, founded Best Bees Company	2012	702,741
96	Species extinction	For the love of birds	Washington Wachira	Kenya	Ecologist	2017	710,973
97	Species extinction	Why bees are disappearing	Marla Spivak	USA	Bees scholar	2013	2,489,230
98	Urban sprawl	How to protect fast-growing cities from failing	Robert Muggah	Canada	Megacities expert	2014	930,729
99	Waste production and disposal	We can recycle plastic	Mike Biddle	USA	Plastics recycler	2011	990,695

Source: Prepared by the authors

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TEL (Technology-Enhanced Learning)

▶ Technology-Enhanced Learning and Education for Sustainable Development

Transaction Spillover

▶ Externalities and Sustainability Processes

Transdisciplinarity and Sustainable Development

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Introducing Transdisciplinarity: Beyond Multi- and Interdisciplinarity

According to Thomas Kuhn, practitioners of a scientific discipline share symbolic generalizations, models and exemplars, which define the problems and possible solutions offered by their discipline (Kuhn 1970; Aram 2004). Disciplines are the basic building blocks of the academic knowledge production. Most commonly, the distinction between multidisciplinary, interdisciplinary, and transdisciplinary research is made as follows. Multidisciplinary research is considered as a loose collection of distinct disciplinary

components, without further efforts for integration between these components. Interdisciplinary research in contrast refers to a more synthetic intent to integrate knowledge from different disciplines, by a more or less integral relationship between knowledge sources (Aram 2004; Bammer 2013; Li and Sakamoto 2015; Edelenbos et al. 2017). Inter- and transdisciplinarity share the common idea of an opening or a transgression of the boundaries between disciplines. But whereas interdisciplinary research mainly focuses on articulating the contributions of different academic disciplines into one coherent framework, transdisciplinary research wants to go further in this synthetic endeavor by integrating different forms of disciplinary academic knowledge with nonacademic forms of knowledge (Popa et al. 2015). This integration of nonacademic knowledge is realized by involving a diversity of social actors – not only scientists but also citizens, policy makers, resource managers, private companies, and nongovernmental organizations – in a joint knowledge production process (Edelenbos et al. 2017). The involvement of different kinds of stakeholders is considered a necessary contribution to both the quality and legitimacy of the knowledge that is needed to generate sustainable solutions for complex realities (Ayre and Nettle 2015; Cundill et al. 2015).

In what follows, first the close relationship between transdisciplinarity, integrating different kinds of knowledge, and sustainable development, involving multiple actors, will be highlighted. In the next part, transdisciplinarity is presented as an alternative approach to counter the negative consequences of the disciplinary specialization, dominating modern Western science, for sustainable development. Then the complex, "wicked" nature of sustainability-related problems is analyzed as a driver for transdisciplinary research. The importance of linking different ways of knowing, including also non-Western ways of knowing that reinforce a holistic approach to the environment, is emphasized subsequently. Finally the main (epistemological, psychological, cultural, and institutional) barriers that hamper the spreading of transdisciplinarity are presented.

Strong Sustainability and Multi-actor Sustainable Development

The current concepts of sustainable development are mostly derived from the definition by the popular Brundtland report (World Commission on Environment and Development 1987) as "development that meets the needs of the present without compromising the needs of future generations." Sustainable development refers to a holistic approach to the complex problems that challenge the future of human societies. It should lead the world to a new kind of human-ecosystem equilibrium.

Sustainability is a contested concept, and the sustainable development approach has been criticized for giving pretexts to the business world to continue doing business as usual (Lankoski 2016). As a reaction to this critique, gradually more emphasis has been put on issues of equity, social justice, and planetary ecological boundaries. Sustainability defenders advocate for a strong concept (substitutability of nonrenewable natural resources is not tolerated) of absolute sustainability (not evaluated by comparing with other actors' efforts but with absolute standards, such as planetary boundaries) and with a broad scope (all relevant considerations, environmental as well as social and economic, have to be taken into account simultaneously) (Lankoski 2016). Sustainable development is then conceived as a joint global challenge for all social actors worldwide to develop together a more sustainable way of producing and consuming. This approach is replacing the former dominant development approach targeting the poor "underdeveloped" countries in the Southern hemisphere to become developed according to the model conceived by the rich, industrialized countries of the North, as this last model has proven to be unsustainable on a global scale.

The new approach to sustainable development is considered a collaborative challenge for a diversity of actors worldwide, as expressed by the Sustainable Development Goals of the United Nations (SDG, also known as the UN Agenda 2030) that have followed the Millennium Development Goals. The SDG's consist of 17 global

goal sets, like poverty eradication, good health, climate change, etc. (http://www.un.org/sustainabledevelopment/sustainable-development-goals/). Although each goal has its own targets, taking care of the interrelationships between the different goals is of preponderant importance. The last and most overarching of the 17 goal sets, "Partnerships for the goals," focuses specifically on the necessary collaboration to reach all the other goals. The importance which is given to collaboration between social actors for sustainable development in the framework of the SDGs might explain the interest in transdisciplinarity as the approach for mobilizing and integrating the knowledge which is necessary to reach that kind of development.

Short History from Positivist Disciplinary Knowledge to Transdisciplinarity for Sustainable Development

The history of transdisciplinarity goes back to the second half of the twentieth century, with philosophers of science like Michael Polanyi (1966) pointing to the need of transcending disciplinary boundaries. Only recently from the beginning of the twenty-first century, the concept became popular in the academic community, specifically related to the domain of sustainability (Polanyi 1966; Bernstein et al. 2014; Klein 2015).

Since the Age of the Enlightenment, positivism has dominated knowledge production in Western societies. It was the motor for starting the Industrial Revolution in the eighteenth century. Although positivism found its origin in the natural sciences, its application in the human and social sciences from the nineteenth century onwards supported the installation of the social infrastructure (scientific management) alongside the material infrastructure (machines) that is necessary for the mass production of goods and services. Positivist knowledge is based on experimentation with specific instruments to find general laws that are expressed by specialist language. Compartmentalization of reality in different disciplines and the exclusion of different modes of experiencing the world and expressing these experiences (in a way that is aesthetic, creative, legal, spiritual, etc.) are at the reverse side of the modern way of knowing (Latour 2013). The monopoly of disciplinary scientific knowledge to inform policy has been criticized for leading to a technocracy that does not take into account adequately the complex and continuously changing nature of reality (Richardson et al. 2005). This has become even more problematic in the current interconnected global society, with high degrees of interdependence, uncertainties, and ambiguities. As a consequence, sustainability problems are attributed precisely to the fragmented nature and simple cause-effect logic of positivist disciplinary sciences.

To reverse this situation, the plurality of knowledge cultures that characterizes our human existence is deemed necessary to be taken into account. Especially when it comes to dealing with environmental problems, the ancestral wisdom of indigenous knowledge, which is rooted in millennia of intimate contact with the natural environment, must not be neglected (Dewulf et al. 2005; Brugnach et al. 2014). The UN Conference on Environment and Development in Rio (1992) already emphasized the importance of indigenous knowledge to be linked with the findings of Western science, to produce knowledge for sustainable development (Pohl et al. 2010).

Wicked Sustainability Problems and Transdisciplinarity

The acknowledgment of the complex nature of the problems resulting from interrelated natural and social systems, like climate change, decreasing biodiversity, extreme poverty, financial crisis, and migration flows, has been a strong driver for transdisciplinarity (Bammer 2013; Cilliers and Nicolescu 2012; Klein 2015; Richardson et al. 2005). These problems are usually characterized by a plurality of decision-makers, pervasive uncertainties, spatial and inter-temporal externalities, interplay of human and natural components, and an evolving understanding of policy objectives. They do not enter the scientific realm as

neutral objects of inquiry, but from the starting phase of the problem definition, they are value-laden and guided by a transformational perspective toward a more desirable state of affairs (Rittel and Webber 1973; Popa et al. 2015). It is precisely this coevolution of understanding and alignment of purpose through transdisciplinary research which makes the desired transformational change a real possibility (Cundill et al. 2015).

Rittel and Webber (1973) have called these problems "wicked," because they are not just difficult to resolve, but they are even hard to define. Most of the problems addressed by the SDG's have wicked characteristics (Tulder 2017): they are related to many other (wicked) problems, they are entangled with value questions about the public good and social equity, their causes are globally interconnected but their consequences are highly context-dependent, there are many different – apparently competing – explanations, and responsibilities of public and private actors are not clear. They cannot be answered in an objective way, and as a consequence there is not one best solution for such problems. But although they cannot be solved definitely, they have to be managed in the best possible way, by a transdisciplinary learning process among all involved actors. The ability for dealing with wicked sustainability problems depends on the variety of knowledge perspectives that can contribute in a relevant way and of the connectivity between the knowledge holders to connect the different perspectives in ways which make sense and add value for all the involved actors.

In recent years there is a strongly increasing number of references to transdisciplinarity to tackle the major problems of human societies (Pohl et al. 2010; Bernstein et al. 2014; Trencher et al. 2014; Cundill et al. 2015; Lawrence 2015; Polk 2015). Transdisciplinary research reports are related to a vast array of sustainability problems such as climate change (Serrao-Neumann et al. 2015), water and catchment management (Gray 2008; Ayre and Nettle 2015; Cundill et al. 2015), land use (Gerritsen et al. 2013; Li and Sakamoto 2015), public health (Bammer 2013), and urban development (Polk 2015). The growing interest is also expressed by the formation of international platforms such as Future Earth (http://www.futureearth.org/) and its Program for Ecosystem Change and Society (http://www.pecs-science.org/). There is also increasing support by funding programs such as the International Social Science Council and the Belmont Forum. As a result, sustainability research is stimulating the development of a growing body of transdisciplinary scholarship. This is also resulting in new transdisciplinary academic paradigms, like "ecological economics," that recognize the importance of linking academic with nonacademic, contextualized, and indigenous ways of knowledge and that are becoming increasingly influential in academia and at a policy level (Popa et al. 2015).

Multiple Stakeholders as Knowledge Co-creators

The tendency to recognize the role of non-academic actors in the knowledge creation process is influenced by ideas on new types of (multi-actor) governance in policy studies. Forms of polycentric governance are conceived as an alternative for the common centralistic and hierarchical governments that are criticized for their limited potential of generating the necessary changes in a complex society (Gerritsen et al. 2013). The multi-actor governance concept has led to the idea of knowledge governance, which shares important principles with transdisciplinary knowledge production, like social learning, reflexivity, and boundary management (Gerritsen et al. 2013).

In today's societies there is a growing openness for and interest from nonacademic actors to be actively involved in knowledge production for sustainable development. This can be related to the growing importance of well-organized civil society organizations with a social and ecological agenda. Not only established organizations, like workers' unions and consumer organizations, but myriads of new virtual groups, mobilizing for diverse issues like animal rights, food security, personal health, and well-being, are motivated to contribute their expertise concerning their topics of interest. These organizations are buttressed by

the high education level of (part of) the population (Gray 2008). For example, an estimated 90% of the ever-increasing number of PhD graduates do not end up in an academic career but are potential citizen scientists! As a consequence, citizen groups can often rely on nonprofessional but highly skilled researchers, and the difference between academic researchers and nonacademic, interested citizens becomes blurred.

Not only academically trained citizens are addressed in knowledge co-creation for sustainable development. Different forms of experiential knowledge and non-Western ways of knowing, contained in oral histories and traditional ceremonies, are welcomed in a joint knowledge co-creation process. The participation of indigenous people, with a cosmovision focused on being part and taking care of a healthy environment, will not just add more fragmented information, but it can also reinforce the more holistic relationship with the environment which is needed for strong sustainability. The Intergovernmental Panel on Climate Change (IPCC) recognizes in its reports the necessity to include indigenous knowledge as an invaluable basis to develop mitigation and adaptation strategies for environmental changes (Brugnach et al. 2014).

Barriers for Transdisciplinarity

Notwithstanding the increased awareness of the necessity of transdisciplinary research, the widening array of contexts in which it is applied, and the growth of the number of publications, transdisciplinarity is still far from being mainstream. It is poorly recognized by professional institutions, it is rarely taught in higher education programs, and it is hard to get financial support for it (Gray 2008; Darbellay 2015; Lawrence 2015). In the following parts, we will briefly indicate the main epistemological, psychological, cultural, and institutional barriers that hamper the spreading of transdisciplinarity in the world today.

Epistemological Barriers

Transdisciplinary endeavors confront us with the philosophical question of the commensurability or incommensurability of different types of knowledge: is reality monolithic so that we can register it, measure it, understand it, and talk about it with one overarching frame, or are we deemed to the plurality of reality experiences, and in that case, can the expressions of these plural experiences be meaningfully linked, compared with each other, and aggregated in some way to address complex sustainability problems? Modern positivist sciences have been driven by the conviction of explaining a monolithic reality by a rational, overarching framework. But specialization has driven modern sciences in the opposite direction: the fragmentation of knowledge. Disciplinary specialization makes knowledge very hard to explain in an understandable way and to link it in a meaningful way with the knowledge of other specialists and with the lived experiences of lay persons (Klein 2015).

Transdisciplinary scholars often bypass philosophical debates about the nature of reality in favor of their practices (Aram 2004). They adopt a pragmatist approach involving scientific and extrascientific expertise in collective processes of problem framing and problem-solving through joint experimentation and social learning. Pragmatism challenges the reductionist model of positivism and the presumed dichotomies between understanding and practice and between production and use of knowledge (Popa et al. 2015). In such a perspective, scientific development is not based on predefined, context-independent criteria of rational acceptability, but it is rather rooted in a collaborative process of concrete problem-solving in which participants are led to jointly reframe and connect their understandings.

But this pragmatic approach is not without pitfalls. Each disciplinary paradigm has implicit assumptions about what counts and what is valuable. Transdisciplinarity is not just connecting different disciplinary frameworks, but jointly analyzing and reflecting on the implicit assumptions and value statements of different frameworks (Popa et al. 2015). Without this critical reflection, pragmatic transdisciplinarity risks slipping into "epistemological isolationism," which means that one disciplinary model is imposed over the others, and possibly enriched with fragmented

adoptions from other disciplines (called "epistemological imperialism" by Flood and Romm 1996). For instance, market economic models have been quite dominant in policy research regarding climate change, incorporating borrowings from ecological and behavioral sciences in their global theories, leading to an almost exclusive focus on emissions trading schemes (Anshelm and Hultman 2015).

The required joint reflection on implicit assumptions and value statements confronts us also with psychological and communicational barriers, which will be explained in the next section.

Psychological and Communicational Barriers

There has been too little concern about the psychological and communicational challenges that need to be addressed in order to achieve the integration of different types of knowledge in transdisciplinary research projects (Lawrence 2015). As different disciplines and disciplinary paradigms express a persuasion about what is valuable knowledge and how such knowledge can and should be created, transdisciplinary research efforts repeatedly lead to quarrels among scientists with different backgrounds about the validity of each other's conceptual frameworks (Gray 2008). This is due to a limited openness to listen to each other and a limited willingness to really commit to a joint problem (Gerritsen et al. 2013). This resistance is explained by the formal education and personal ambitions of individual researchers in academic institutions (Lawrence 2015). Through their academic training, researchers become deeply identified with their own paradigmatic belief. As a consequence they find it hard to accept the knowledge claims based on very different assumptions and methods in other disciplines or outside academia.

The barrier between scientific researchers with different disciplinary or paradigmatic backgrounds in a common research project can be a greater obstacle for the communication and understanding between them than the boundaries between these researchers and their stakeholders (O'Brien et al. 2013), for example, natural scientists may find it easier to engage with ecologists outside academia, than with the social scientists in their academic research team (Prins et al. 2005).

Cultural and Linguistic Barriers

Cultural and linguistic barriers can result from the differences between academic cultures in different parts of the world (Lawrence 2015). Even about the meaning and need of transdisciplinarity, there seems to be quite some divergent understanding in the English-speaking world, between Britains, North-Americans, and Australians, let alone between Anglo-Saxon, French-Mediterranean, German, and other intellectual-linguistic traditions.

However, the differences between Western scientific disciplinary ways and non-Western ways of knowing and dealing with reality in other parts of the world constitute an even higher barrier for developing transdisciplinary insights. In the domain of sustainability, there is a special interest in indigenous ways of knowing, as they are considered important repositories of ancient wisdom based on living in close contact with the surrounding nature. In practice indigenous ways of knowing are very hard to connect with Western, scientific ways of gathering knowledge because of the intertwined effects of different framing and scaling reality (generalizing knowledge for global policies in contrast with contextualized knowledge rooted in local experience) and power differences between Western academic and local knowledge holders (Dewulf et al. 2005; Brugnach et al. 2014). In the next section, we will focus on this important barrier.

Power Differences

Knowledge production is affected by the power dynamics between the actors in a transdisciplinary knowledge creating community. Power refers then to the different abilities of the actors within such communities to get their needs attended before the needs of others (Mitchell et al. 1997). Transdisciplinary collaboration is often affected by deep power asymmetries in the interactions between "experts" and "non-experts" in transdisciplinary settings. These power differences are a particular challenge when transdisciplinary communities are the result of an external initiative. On the contrary, communities that develop

spontaneously "from within" are less likely to face this challenge, because such power asymmetries would probably prevent the development of such communities (Cundill et al. 2015).

Power issues and the domination of transdisciplinary initiatives by certain disciplines or other dominant stakeholders have not been widely debated during the last decade. However understanding how power asymmetries influence the co-production of knowledge and learning to deal with them adequately is necessary to ensure the transformative capacity of transdisciplinarity (Lawrence 2015)

Institutional Barriers

Institutional barriers in the academic world refer to university structures, like faculties, departments, and research units, but also to scientific journals that function as disciplinary islands, rewarding disciplinary excellence and specialization while disincentivizing transdisciplinary efforts (Gray 2008; Darbellay 2015; Lawrence 2015). These academic structures find their origin in the nineteenth century era of industrialization. Hierarchical bureaucracies were designed to maximize the efficiency of standardized mass products, responding to clear demands in stable markets. The underlying principles were further developed and pervaded the whole society, including universities. With the increasing complexity of society, university bureaucracies have evolved toward so-called professional bureaucracies, with a high number of specialized departments and integrating mechanisms. However, the uncertain, ambiguous, and rapidly changing "turbulent" character of the problems with which the current society is confronted demands more flexible structures, with open boundaries and boundary spanners, not only between disciplinary groups but also with non-academic actors. Innovative knowledge in the business world is generated precisely in this kind of environments (Bouwen and Fry 1991).

Redesigning (university) structures to more adequate environments for transdisciplinary collaboration will only function when these changes are well aligned with corresponding changes in the entire "hard" and "soft" infrastructure of the organization (expressed by the 7S-model of Peters and Waterman (1982): Structure, Strategy, Systems, Skills, Style, Staff, and Shared values). Starting with the shared values might be most challenging as the academic culture is deeply influenced by the dominant societal emphasis on competition for scarce resources. Academic researchers have to compete with colleagues based on the number of publications as the measure of their performance. This does not stimulate them to engage in open processes with external stakeholders that consume time and energy, with uncertain outcomes. Competition for scarce resources also leads to protective measures of intellectual property, through copyrights and patents, which is at odds with the need for collaboration between academic groups and with external stakeholders in transdisciplinarity.

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Transdisciplinary

▶ Multi-disciplinarity

Transdisciplinary Processes for Sustainable Development

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Definition

Transdisciplinary processes for Sustainable Development refer to the relational characteristics of the collaboration between academic and non-academic actors that are necessary to address the

complex conceptual, value-laden and action-driven challenges of sustainable development.

Introduction

Sustainable development assumes a holistic approach to the complex human-ecosystem interrelationships. Such an approach requires an intense collaborative effort between a variety of academic and nonacademic actors with different knowledge traditions, perspectives on, and interests in the way they experience and frame sustainability-related issues. This is contrary to the dominating practices in higher education based on specialization in disconnected disciplines. Higher education requires research and learning practices that stimulate specialists from different fields to engage in collaborative activities with nonacademic actors that contribute to sustainable development. Due attention has to be given to the qualities of the relationships between the involved actors. These qualities have to be considered in relation with the conceptual and action-driven aspects of collaboration and sustainability (Senge et al. 2007).

In the following sections, first a social-relational process perspective on collaboration is explained, and then its relevance for sustainable development is clarified. Different perspectives (individual, interactional, thematic, and contextual) on research are identified that enable a variety of academic and nonacademic actors to engage in a joint exploration of complex realities. Subsequently, the relational tasks and challenges in the consecutive phases of a collaborative research process are described. Finally we give attention to issues of leadership and boundary management in transdisciplinary processes for sustainable development.

A Social-Relational Perspective on Transdisciplinary Collaboration for Sustainable Development

Various authors argue for giving due importance to the social-relational characteristics of collaborative processes in transdisciplinary research for sustainable development. Indeed, transdisciplinary research might be quite demanding for the quality of the relations between different research teams and with external stakeholders (O'Brien et al. 2013; Cundill et al. 2015; Lawrence 2015; Edelenbos et al. 2017). Collaboration is then conceived as a process in search for synergetic solutions between different actors involved in a shared complex problem through the joint appreciation of different but complementary viewpoints (Gray 1989; Huxham and Vangen 2005; Gray and Purdy 2018). Through an emergent and possibly conflictive process, actors increase their insights in the intertwined nature of complex problems and their collaborative capacities while negotiating mutually beneficial agreements.

Collaborations for sustainability draw together partners with very different but relevant attributes. "The point of working with someone else is that they have a perspective, skills, resources or some other attribute that contributes something relevant to addressing the research problem, either in improving or understanding about it or in implementing that understanding in decisions and action" (Bammer 2008). Participants acknowledge the advantages of hearing different perspectives and the opportunity to gain a better understanding of others' views (O'Brien et al. 2013).

In these collaborative research endeavors for sustainability, universities have to partner with business companies, governments, and NGOs to confront complex sustainability-related problems for which isolated efforts are inadequate. Such cross-sectoral groups, with a shared commitment towards a joint socioecological challenge, have to engage with one another to coproduce knowledge for policies and practical applications. Barriers between traditional knowledge roles – researchers as opposed to stakeholders – and between knowledge forms – scientific knowledge as opposed to experiential knowledge – (O'Brien et al. 2013) must be broken down. The participants will be involved in an ongoing, iterative process of issue framing, knowledge production, and knowledge application. As they are operating in different areas of practice, the jointly developed knowledge

will have to be applicable in such varied areas as science, state institutions, commercial enterprises, and civil society activism (Senge et al. 2007; Cundill et al. 2015).

The relational qualities of the interactions among the participants must stimulate them to reflect on the – often implicit – mental models of their discipline, and on how these different mental models can be linked with each other, to generate a shared vision (Senge et al. 2007). The insight that the relational qualities in small group processes is decisive for the effectiveness of organizations goes back to the seminal work on Group Dynamics and Organization Development by Kurt Lewin and followers (Edgar Schein, Ronald Lippitt, Chris Argyris, amongst others). Although Organization Development is best known in management studies, Lewin conceived his process-driven intervention methodology originally in contexts of social development, to deal with issues like racism and authoritarianism (Cooke 1998). The democratizing and participatory vocation of Organization Development is part of its DNA and has inspired influential contemporary scholars like Peter Senge, Otto Scharmer, and Etienne Wenger to further develop it into innovative collaborative methodologies for broad sustainability-related challenges on the societal level (Wenger 1998; Senge et al. 2007; Scharmer and Kaufer 2013).

Senge et al. (2007) argue for a transformational model of collaboration, in contrast with a transactional model, when sustainable development is at stake. Transactional collaborative networks operate like markets: they are only viable when actors perceive that the benefits of collaborating exceed the costs of the invested resources, time, and risks. From this perspective, a collaborative effort is attractive for participants when there is a compelling value proposition, a clear "business case" for them. Transactional mechanisms may function to improve existing systems by enhancing their (eco-)efficiency; however, they are not able to drive the transformational changes at system level necessary to reach sustainable development. By contrast, a transformational logic revolves around a larger purpose that matters not only to all the direct participants in the collaboration but also to society at large, including vulnerable and voice-less social groups, and all living beings on our planet, including future generations. A transformational logic recognizes the inalienable rights of all living beings to survive and flourish as part of a healthy global ecosystem, even if they do not have the possibility to defend these rights. Participants in a transformational collaboration are not indifferent to their own benefits and costs, but their primary motivation to collaborate comes from a commitment to a transcendent aim of generating sustainable solutions, and from the awareness of the long-term strategic importance of the collaboration for their own organizations and for the larger system in which they are embedded (Folke et al. 2009; Craps et al. 2016; Williams et al. 2017).

Different Perspectives on Research to Engage Academic and Nonacademic Actors

One of the main challenges of transdisciplinary research for sustainability consists in linking the generalizing claims of the academic scholars with the experiential and contextualized insights of other knowledge holders, like local community members, social activists, citizen scientists, etc. Actively involving local actors and other stakeholders in the study of their own reality is indeed necessary to address adequately the context-dependent issues of social-ecological systems and the interests of these stakeholders as they map out their future livelihoods (Chaffin et al. 2016). Contextualization also makes knowledge "actionable" for the different involved actors (Dewulf et al. 2005), by connecting the interests of the scientific scholars with the interests of the other stakeholders (Aram 2004; Klein 2015).

Transdisciplinary research can draw on a long tradition in participatory action research (Whyte 1989). In the domain of public policy, Arnstein's (1969) seminal "ladder of participation" has greatly influenced thinking about participation in research and policy making. This ladder indicates increasing levels of public participation. The lowest level of participation in research by an actor

consists in just being informed about the research and passively giving information, but without any influence on the research question and the way results will be applied. The highest level consists in determination of the research agenda, self-organization of the research, and decision-making regarding the consequences of the outcomes by the stakeholder community (Arnstein 1969; Craps et al. 2016).

These increasing levels of participation and collaboration of academic and nonacademic actors in joint research to grasp complex realities imply the combination of different perspectives on knowledge acquisition. The distinction between an individual, an interactional, a thematic, and a contextual perspective, identified by Ruth Cohn in the Theme-Centred-Interaction model (Lawrence 2015) is useful for this purpose. These perspectives are related with the distinction in action research between first person (subjective) knowledge, second person (inter-subjective) knowledge, and third person (objectifying) knowledge (Chandler and Torbert 2003). Otto Scharmer conceives these perspectives in a similar way as different levels of awareness about the needs of society to attain sustainable development (Scharmer and Kaufer 2013). Each perspective puts its own requirements on the transdisciplinary collaboration. In the following paragraphs four complementary research perspectives and their requirements are explained more in detail.

Research from an individual perspective helps the researcher to become aware of one's deeper interests and needs (the "I" level). Chandler and Torbert (2003) describe first-person research as: encompassing skills and methods that address the ability of the researcher to foster an inquiring approach to his or her own life, to act consciously, and to assess effects in the outside world while acting. The key in these practices is to reflect critically on issues that make us vulnerable and to reconsider the ways in which we live our lives. The increasing interest in meditative practices like mindfulness, inspired by Buddhist and other spiritual traditions, by individuals and groups also in academic environments dedicated to sustainability-related issues, can be linked with this interest in cultivating "I"-knowledge to connect deeper with oneself, the others, and the whole ecosystem (Scharmer and Kaufer 2013).

Transdisciplinary research from an interactional perspective reflects on how the relations between the involved actors affect the outcomes of their joint initiative (the "We" level). Second-person research involves creating communities of inquiry in which the participants reflect on the inclusion and exclusion of actors, explore the undesirable side effects of the application of their models for other actors, deal adequately with power disparities and conflicting interests and talk about issues of leadership, dependency, and counter-dependency in the group process. The aim is to enhance opportunities for mutual transformations. This process must take place in a supportive, self-disclosing, and open way to support reflexive social learning (Argyris and Schön 1978; Chandler and Torbert 2003). Below the importance of reflexive social learning for sustainable development in higher education will be explained more in-depth.

Research from a thematic perspective analyzes shared purposes and concerns (the "It" level). In third-person research, researchers analyze a reality from the outside, with specific instruments and following rules which are agreed upon in a disciplinary community. It has proven its value to generate instrumental knowledge for the creation and steering of "simple" systems, according to a linear cause-effect logic, according to a mechanistic metaphor of reality. This external perspective on reality is insufficient when we have to understand, learn about, and adapt to complex changing systems, the core challenge of sustainability. It has then to be complemented with an agent-based (inter-subjective) perspective "from within." However a (post-)positivist approach, which is still dominating the majority of academic natural and social sciences, tends to consider an objectifying third person perspective as the only one to generate valid knowledge. It does not encourage integration with first-person research, in which researchers reflect on their own practices, and with second-person research, which pays attention to the interactions between the researchers and with the subjects they are studying

(Chandler and Torbert 2003). As a consequence, a narrow positivist approach to the study of sustainable development may hinder the necessary transdisciplinary collaboration. Valid third-level knowledge, based on critical analysis and fact checking, is necessary but it has to be exchanged in high-quality dialogues among knowledgeable and interested participants, who listen "with an open heart and open mind" (first level) and deep empathy for the others (second level) (Scharmer and Kaufer 2013).

According to Otto Scharmer's U-theory (2013), the participants in a collaborative research process should evolve through and beyond the former stages to arrive at a stage of "generative listening." The collaborating group will experience then collectively a deeper connection with the broader context and will become deeply aware of its systemic embeddedness (fourth level, global/contextual). This stimulates the participants to grasp not only what has happened in the past, and the reality as it is now, but also a reality that is becoming and that could be possible in the future. Research is then linked with action. Once aware of "the deeper realm of emergence," groups engage in co-creating solutions through prototyping and scaling up successful alternatives that contribute to the sustainability of the broader eco-system. (Scharmer and Kaufer 2013)

Relational Challenges Throughout Collaborative Research Processes

Various authors have described models of collaborative research processes that describe distinct periods of sequential activities. Lawrence (2015) describes a seven step process: (1) identification of partner organizations, (2) identification of cases, (3) formulation of research questions and the boundaries of each case, (4) choice of analytical frameworks, (5) data collection, (6) analysis of case studies and synthesis of results, and (7) discussion and communication of results. Ayre and Nettle (2015) propose a model of a dynamic process for knowledge integration in five phases: (1) establishing the imperative for integration, (2) coordinating different disciplinary and other knowledge commitments, (3) consolidating arrangements for integration, (4) prioritizing outputs from integration, and (5) representing outputs of integration. Gray (1989, 2008b) proposes a more generic four phase model for collaborative problem solving and decision-making: (1) problem setting, (2) direction setting, (3) implementation, and (4) institutionalization. The critical tasks in the problem-setting phase include identifying the relevant partners and getting them to commit to a collaborative partnership. Direction setting involves exploring the issues and reaching the necessary agreements among the participants to address these issues. Implementation entails putting those agreements into place and ensuring follow-up of these agreements. Institutionalization has to capture structuring and regularization of ongoing interactions among stakeholders and learning for the replication of similar partnerships in other contexts.

These models pay limited attention to the relational process between the participants, that – as described above – is of decisive importance in transdisciplinary research for sustainable development. Bouwen and Taillieu (2004) observe that natural scientists and engineers have a tendency to restrict their attention to the content of the problems. The distinction made by these authors between activities focusing on the content of the problems and "relational" activities in transdisciplinary projects is useful to highlight the challenges and tasks to deal adequately with the social relations between the partners in a collaborative research process: (1) getting attention and raising awareness of all relevant stakeholders, (2) mobilizing these stakeholders and getting their commitment to collaborate, (3) legitimating conveners and stakeholders, (4) dialoguing to explore the diversity of knowledge frames and interests, (5) connecting frames and interests, (6) negotiating roles and identities, (7) guaranteeing commitment of constituencies for the implementation of the proposed solutions, and (8) aligning efforts and agreements. Although task content and social relations can be distinguished analytically, they can and should not be separated in practice. For that reason, Bouwen and Taillieu (2004) argue for "relational practices," which are task-oriented

actions that foster the collaborative process by the high quality of the relations between the involved actors and the space for reflexivity.

Investing sufficient time and resources for face-to-face meetings between participants in a transdisciplinary project is of fundamental importance to cultivate these high-quality relations between research groups and with external stakeholder groups. For the same reason, long-term engagement in transdisciplinary projects is argued for as developing trust and mutual understanding is a slow and tricky process (Edelenbos et al. 2017). Joint field visits of researchers belonging to different disciplines, together with external stakeholders, are repeatedly mentioned as important opportunities, not only to know each other better but also to exchange contextualized information (Bouwen 2001; Dewulf et al. 2005; O'Brien et al. 2013). Participatory mapping techniques are highlighted because of their potential to integrate scientific information with stakeholder knowledge, contributing to a sense of legitimacy and inclusive ownership of the final products (Cundill et al. 2015).

Sufficient concern should also be given to the fundamental role that reflexivity plays in transdisciplinary research for sustainability (Gerritsen et al. 2013; Cundill et al. 2015; Popa et al. 2015). Popa et al. (2015) define reflexivity in a broad sense as the acknowledgement, critical deliberation, and mutual learning on values, assumptions, and understandings that enables the generation of "new meanings, new heuristics, and new stakeholder identities." The need for a more systematic integration of reflexive processes into transdisciplinary science can be advocated on epistemological, normative, and pragmatic grounds (Popa et al. 2015). The epistemic role focuses on extending the community in order to be more able to grasp the complex and uncertain nature of the problem situation. The normative role emphasizes the importance of democratic participation, social relevance, and legitimacy-building. The pragmatic role considers the mobilization of public support and public trust in the expertise that is developed and in policy interventions that rely on such expertise. This leads the authors to distinguish four purposes for reflexivity in transdisciplinary research: (1) to develop a shared understanding of a problem, (2) to reflect on the social relevance of the problem framing, (3) to set up joint social experiments and collective learning processes, and (4) to create a research agenda with a critical and transformative character. This last form of reflexivity does not only include acknowledging the values, ideologies, and power structures that shape the organization of the research process but also clarifying and developing agreements on an agenda of social change and sustainability transitions. For these purposes, a combination of conventional consensus-oriented deliberative approaches and more open-ended, action-oriented, transformative approaches to reflexivity is recommended.

Leading and Facilitating Transdisciplinary Communities

Various authors point to the inspiring concept of "communities of practice" for transdisciplinary research teams (Dewulf et al. 2005; Cundill et al. 2015; Lawrence 2015; Polk 2015). This concept draws on the situated learning theory of Lave and Wenger. It was further developed by Wenger (1998, 2000) to deal with the challenges of sustainable development. Communities of practice are emergent social entities resulting from interactions that arise out of the concerted efforts and shared interests of groups of individuals to engage in a process of collective learning. Learning communities become evident when people start asking for help and offering help to each other, and openly discuss real problems with which they are confronted. Over time, they nurture common commitment and relationships based on respect and mutuality (Senge et al. 2007).

Communities of practice are characterized by different levels of participation. Often only a relatively small core group is highly active. The core members provide informal leadership and ensure the legitimacy of the community to the outside world. Other "full" members participate regularly and contribute meaningfully but without the same engagement as the core members. A third category of "peripheral" members is also important

for transdisciplinary communities of practice because they tend to use the knowledge produced by the learning community in their policy work. In this way, they enhance the reputation of the transdisciplinary community in terms of its credibility, legitimacy, and saliency (Cundill et al. 2015). Peripheral members may also transform into full or core members and in this way they expand and replenish the membership of the community. Other people may not be considered as members but have an interest in the activities of the community. At any moment, they may become peripheral, full, or even core members, depending on the evolving topics with which a community is dealing. Some people will move through all these layers of membership over time, at times playing an active role during a given topic or activity and at other times playing a more passive role. For that reason, successful communities of practice encourage peripheral participation and develop consciously opportunities, for those on the sidelines to contribute (Wenger 2000).

As learning in communities of practice is a result of the interest and the initiative of its participants, such communities cannot be imposed by an external authority. Setting up a transdisciplinary research project or program will not in itself generate transdisciplinary learning (Senge et al. 2007). But although formal administrative authorities do not lead the learning process of communities of practice, they still have an important role in it. A relational process perspective on transdisciplinarity draws the attention to how leadership works in the interplay between different actors to generate learning between different groups. Complexity Leadership Theory (CLT) offers a suitable framework for this purpose, as it views leadership as resulting from the concerted and collective activities of sets of network members who actively strive for innovative solutions, provoking a collective impulse for action and change (Uhl-Bien 2006). According to CLT, three complementary leadership functions are situated in different types of leadership networks: administrative leadership in formal networks, adaptive leadership in change alliances, and enabling leadership in shadow networks. The main functions and tasks of these three different leadership networks will be presented in the following paragraphs.

Administrative leadership refers to the power and authority derived from top positions in hierarchical structures. Members in formal managerial positions can allocate resources to different parts of the organization by their strategic planning. To favor transdisciplinary learning, administrative leaders, who are mostly concerned with the survival and continuity of their organization, must be aware of the necessity of transformational changes in their organization to respond to the challenges of the broader context in which they are embedded. They have to assign resources to innovative, experimental niches in their organization, functioning with informal structures, and open boundaries.

Adaptive leadership refers to the interactive and generative dynamic that takes place throughout the organization in innovative "change alliances," emerging out of the clash of discordant ideas, knowledge, and initiatives. This is the kind of leadership enacted by the core members of transdisciplinary research and learning communities. Because of the dynamic and "ad-hoc" nature of these groups, they depend largely on the quality of the relations of its members and the degree with which they can dialogue, listen to each other, and acknowledge one another's ideas (Bouwen and Taillieu 2004). Leadership here consists largely in visioning as an appreciative task that appeals to participants unleashing their curiosity and creativity to generate scientific breakthroughs and a new understanding of a specific problem area by connecting different types of knowledge (Gray 2008a). This implies promoting divergent thinking, risk taking, and challenging established methods.

Enabling leadership, the third leadership function in the CLT framework, contributes to the transdisciplinary process by facilitating the relations inside transdisciplinary teams as well as between these teams and the administrative leaders of their constituencies. Enabling leaders can fulfil several tasks to improve transdisciplinary processes, like: designing meetings with external stakeholders, determining what ground rules might be useful, developing trust among

the partners, caring for the stability of the group even when members come and go, mediating conflicts that are likely to arise as members strive to understand and integrate concepts, frameworks, and methodologies that may threaten their disciplinary comfort zones and ensuring that there is effective communication and that necessary information is transferred among the partners (Gray 2008a).

Enabling leadership calls the attention to the importance of boundary spanning and brokering in transdisciplinary initiatives. Transdisciplinary groups can indeed be considered as boundary organizations that exist at the borders of different social worlds and mediate the interactions between these worlds despite their diverse purposes, incongruent values, or eventual mutual incomprehension (Cundill et al. 2015). They can exist with the help of boundary objects, boundary-spanning activities, and brokers.

Boundary objects are models, classification systems, interactive maps, and so forth that enable different communities to interact despite differences (Wenger 2000; Craps et al. 2004; Cundill et al. 2015). Boundary-spanning activities are critical for transdisciplinary initiatives because they pass information from, and to, groups outside their boundaries. Gray (2008b) identifies the following boundary-spanning tasks as key for transdisciplinary teams are: gaining and maintaining sound institutional commitment and support, acquiring funds to manage emerging areas of research and training, devoting adequate attention to and securing funds for infrastructure, and building bridges to other centers and new disciplines.

Brokers are persons that build linkages and increase information flows among previously unrelated parties (Gray 2008b). Because they occupy "structural holes" in social networks, they have access to a wider array of information than others within a network and, because they have one foot in each of several groups, they can decipher differences and translate among them. They can also help solving misunderstandings and overcoming the tensions due to power and status differences among diverse groups. Brokers with experience in both scientific and policy communities, can improve the integration of policy considerations in the transdisciplinary knowledge (Cundill et al. 2015). Organized groups of engaged and well-informed local inhabitants can fulfil essential brokering functions by bringing the worries of the local communities under the attention of the transdisciplinary teams (Sips et al. 2013). To the extent that the members of transdisciplinary teams have diverse contacts outside their team, they may all leverage various brokerage roles to import novel insights into the team (Gray 2008a).

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Transferable Skills

▶ Soft Skills and Sustainable Development

Transferring Knowledge for Sustainable Development

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Definition

Transfer of knowledge to sustainable development involves a complex, critical, and reflexive approach to environmental issues, collaborating so that individuals can really understand the interaction of social, economic, and environmental aspects inherent to a more sustainable society conception. This process must occur in the most diverse learning spaces, such as higher education institutions, which are essential, among other

factors, for research development, knowledge dissemination, and professionals and citizens' training committed to social change toward sustainability.

Introduction

According to Duvoisin (2002), as humans ceased to worry about nature as their place of residence and came to see it as a profitable resource supplier, they began the socio-environmental problems and the destruction of the planet. For Motta et al. (2011), increase in the consumption of planet's natural resources presents, as a consequence, degradation and environmental pollution. According to UNESCO (2015), unsustainable development processes put pressure on natural resources, while unsustainable patterns of production and consumption – especially in developed countries – threaten the fragility of natural environment, intensifying poverty in other localities.

Aiming to find solutions to minimize the various socio-environmental problems, ensuring that the present and future needs of humanity are met – through rational use of natural resources – the concept of sustainable development brings a perspective of change to the way humans have interacted with environment in which they live (World Commission on Environment and Development 1987).

According to Labanauskis (2017), the concept of sustainable development evolves, and, during Earth Summit, in Rio de Janeiro – 1992 – this concept was established as a key ideology of long-term social development. This statement was adopted, establishing the basic principles of sustainable development.

Also in 1992, Agenda 21 – which is composed of 40 chapters – provided a fundamental perspective for sustainable development promotion: education. Chapter "► Wellbeing and Sustainability" specifically addresses issues regarding promoting education, public awareness, and training and identifies three program areas for learning, in addition to the prerequisite necessity to achieve universal participation in education (education for all). The three areas are reorienting education to sustainable development, increasing public awareness, and promoting training (Gough and Scott 2007).

The United Nations General Assembly, in December 2002, adopted Resolution 57/254, in which it proclaimed the United Nations Decade of Education for Sustainable Development, from 2005 to 2014. The resolution was adopted because United Nations have seen education as the key – sine qua non condition – for sustainable development. UNESCO was chosen to lead the Decade and to draw up an international implementation plan. This document was the result of extensive consultations with United Nations agencies, national governments, civil society organizations, NGOs, and specialists. According to the international education plan for sustainable development, it is a vital and constant effort that challenges individuals, institutions, and societies to look toward a sustainable future (UNESCO 2015).

In 2015, Agenda 2030 for Sustainable Development was elaborated. It is a document signed by world leaders with a 15-year plan of action to protect the planet, based on 17 Sustainable Development Goals (SDG). The agenda seeks to create means for growth, inclusion, and sustainable economy, creating decent work for all, according to the development and capability levels of each nation. It is worth mentioning that Agenda 2030 goals include ensuring inclusive and equitable quality education (United Nations 2015).

In this sense, higher education institutions (HEIs) play a fundamental role regarding the development of knowledge related to sustainable development, as well as the education and transfer of this knowledge to the various social actors directly and indirectly involved with these institution activities.

Sustainability challenges that human society is facing are increasingly urgent. Thus, given this urgency, of tackling sustainability challenges in diverse and diffused ways, there are opportunities for different stakeholders and institutions of society to engage in new ways. Higher education institutions have a particularly interesting potential to facilitate society's responses to the

multiplicity of sustainability challenges faced by communities around the world (Stephens et al. 2008).

For Menezes and Minillo (2016), university can play a significant role and present itself as a relevant actor in the promotion of sustainable development, as well as contribute to the implementation of SDGs. Actions and activities developed within university environment, involving teaching, research, and extension, carry great transformative potential.

It is also worth mentioning that higher education is one of the sectors in which the concept of sustainable development is more widely analyzed and implemented (Amaral et al. 2015; Lukman and Glavic 2007; Holm and Martinsen 2015). According to Tauchen and Brandli (2006), HEIs are seen as specially equipped agents to lead the way in pursuit of sustainable development. Within this perspective, Sorrentino and Nascimento (2010) also emphasize that higher education institutions should collaborate in the search for solutions and the definition of responsibilities for development of critical thinking that makes it possible to face causes of environmental degradation.

In view of the above, the present work brings, first, a reflection about environmental education, knowledge for sustainable development, and the importance of higher education institutions in this context. Following this, a case study developed in the field of higher education is presented, which can contribute to understanding these institution's role regarding knowledge transfer aiming at sustainable development.

Environmental Education and Knowledge for Sustainable Development

According to Cascino (2005), nowadays, environmental issues already reach communities with moderate strength. The fragility of man's nature and survival need is becoming more and more evident, and this awareness over decades has given rise to the environmental movement. Addressing themes like generation's future and sustainable use of natural resources, environmental education is gaining more and more importance in environmental issues, giving an image to the problems faced and being assisted by governmental institutions, nongovernmental organizations, international organizations, and other groups.

Despite having a dispersed beginning in educational institutions, environmental education has gained strength and solidly structured in schools. Environmental education privileges the understanding of environments and respects the individual and the group, in order to make man take possession of nature again – but in a proper way, with new acquired values, bringing harmony to the parties.

As Saito (2002) reports, from the 1970s, the debate on global environmental problem is related to the social and economic development of nations and how behavior could be changed through environmental education intensification. In this context, the first focus of environmental education was the concern with nature, inserting some environmental topics in science teaching and, sometimes, connecting it to the teaching of geography and art education.

In addition to this vision, it is necessary to take into account the various faces of socio-environmental reality when presenting proposals for the concept understanding and environment protection. In this way, environmental education is essential for fundamental education and concerns a sphere of interactions that is at the basis of personal and social development in relation to the environment in which human being lives. It induces social dynamics, promoting the collaborative and critical approach to socio-environmental realities and a unique understanding of the problems that raise their possible solutions (Sauvé 2005).

The author mentions that environment is the environment of everyday life, at school, at home, and at work. The first step of environmental education happens in this reality, with a renewed, appreciative, and critical view of the place where one lives, favoring social interaction, comfort, safety, and health. To educate one must learn to discuss, to listen, to argue, to convince, and to

communicate effectively through the knowledge of various scientific types. Environmental education happens through reflection and action in a constant cycle of learning that will lead to different attitudes.

In this sense, according to Jacobi (2003), reflecting on environmental complexity leads to an opportunity to understand the attitude of new social actors who are mobilized to take care of nature, involving an educational process articulated and committed to sustainability and participation. The concern for sustainable development represents the possibility of ensuring sociopolitical changes that do not compromise the ecological and social systems that sustain communities.

According to Pelicioni and Philippi Jr (2005), environmental education allows the exercise of citizenship through active individual and collective participation, including the socioeconomic, political, and cultural factors that influence it. Through action-reflection-action processes, environmental education prepares people to demand their rights and fulfill their duties in social participation and representation, influencing public policies and contributing to a democratic culture. In this process, human being is an agent and object of history and has the power to transform it, while is influenced by sociopolitical, economic, and cultural factors.

Environmental education increasingly assumes a transforming function, in which individuals are co-responsible in the promotion of sustainable development. Environmental education focus is centered on awareness, behavior change, skills development, evaluation capacity, and stakeholder participation, which will lead to a change of values. The challenge is to formulate an environmental education that is critical and innovative, formal and informal, and, above all, a political act for social transformation. Its action must seek solidarity, equality, and respect for difference through democratic forms of action (Jacobi 2003).

Ruscheinsky (2004) mentions that educational pedagogy should use the main conflicts expressed through the discourse on political action in order to disseminate critical environmental education. In order to do so, it has to participate in significant events through public visibility, through which it influences a network of organizations articulated by a large range of social actors.

Loureiro (2004) complements this view by addressing transformative environmental education as a constant and collective process through which human being acts and reflects, transforming life reality. It is focused on the problems experienced, the needs, the interests, and the relations of nature and society, as means to seek new syntheses that indicate democratic, sustainable, and fair paths for all.

Jacobi (2005) reports that in some cases there is still resistance from the population of the areas most affected by the constant and increasing environmental damages with respect to this learning. It also represents the possibility of opening stimulating spaces to implement diversified alternative for social participation, as a guarantee of access to information and the consolidation of open channels.

The position of dependence and non-responsibility of some people is often due to lack of information, lack of environmental awareness, and lack of community practices based on citizen participation. Educational actions should aim at changing habits, attitudes, and social practices. It reinforces education oriented to reflect environmental education in face of environmental crisis, insecurity, and uncertainty of current society (Jacobi 2005).

In this sense, it is important to highlight the role of higher education institutions regarding environmental education promotion and, consequently, transfer of knowledge involving sustainable development. “Nowadays, the principles of sustainable development are becoming increasingly important and universities are acting as agents in promoting these principles within society” (Lukman and Glavic 2007, p. 103).

According to Holm and Martinsen (2015), there is a strong and growing global consensus among all countries that environmental issues need to be addressed in their policies. Environmental degradation is still accelerating in many parts of the world, involving different environmental dimensions, resulting in uncertain

(often) but potentially very serious implications. From the perspective of education in general, this means that it is necessary to educate people so that they have a sustainable mentality. In relation to higher education, it means developing the necessary knowledge approach so that the implementation of this education is possible, thus promoting sustainable development and specific valorization of this type of knowledge.

> Universities value knowledge and for that reason they demand clarity about what is known and how. Universities also value the pursuit of knowledge and must, therefore, insist on its present and on-going incompleteness – in face of those who, for whatever reason, wish to extrapolate to final, general truths. Sustainable development touches on all aspects of our intellectual lives and will require us to husband what we know, eschew glib certainties and confront the future with an open, learning orientation. To this extent there is an identity of interest between higher education and sustainable development. (Gough and Scott 2007, p. 173)

Universities have their own environments and are part of a wider environment in which they are inserted. The way they approach and manage environmental issues is conditioned by a number of external factors. This way of conduct also influences areas beyond the academic context. In this sense, it is worth to highlight the reflection proposed by Gough and Scott (2007), in which authors mention that if higher education institutions, for example, place emphasis on reducing energy and water consumption, minimizing their waste and carbon footprints and encouraging recycling, motivated by financial incentives, they can have a very positive return. Besides the financial issue, through these actions, they can also foster opportunities for research and teaching.

In the context of teaching and research on environment, the authors present general points that need to be observed in higher education (Table 1).

In addition to these points, it is important to consider that sustainable development approach in higher education should not be restricted to a particular curriculum, "within departments of economics, or environmental science, or sociology, or politics, but as a fresh and necessary challenge to the way that ideas are classified into economics, environmental science, sociology, politics and so on" (Gough and Scott 2007, p. 167). Graduates of higher education institutions play important roles in society as citizens. University research has impacts on the wider context of social, economic, technological, environmental, and so on policy within which citizenship is practiced and learning process becomes continuous (Gough and Scott 2007).

Transferring Knowledge for Sustainable Development, Table 1 General points for research and teaching in higher education institutions

Universities are concerned with the entire range of possible understandings regarding what "environment" essentially is.
Cross-disciplinary working may be indicated by environmental issues, but just saying that such working is necessary helps very little to make it more likely.
Environmental knowledge that seems true, useful, and generalizable to rich-country academics may be much more questionable in the developing world.
Institutional context in which universities operate is important in determining their attitudes to environmental knowledge, both for teaching and research.
Policy-makers often have an unrealistic and naive view of the relationship linking policy decision-making to research, teaching, learning, and environmental change. So too (sometimes at least) do academics.
Research can be as readily characterized by the assumptions that it makes about the environment as by the discoveries that it makes.

Source: The authors based on Gough and Scott (2007, p. 94)

Cortese (2003) reinforces this issue by mentioning that higher education institutions have a deep moral responsibility to raise awareness, knowledge, skills, and values needed to create a just and sustainable future. The author emphasizes that higher education plays a critical role in making this vision real, but often this role is neglected. The majority of professionals who develop, lead, administer, teach, work, and influence institutions of society are prepared by higher education.

In this context, Stephens et al. (2008) mention that higher education institutions have a unique position in society, since they are extremely important sites for knowledge production, perpetuation, and dissemination. According to

the authors, in addition to these conventional associations of universities and knowledge, higher education institutions have the unique potential to stimulate the synthesis and integration of different knowledge types and to improve knowledge application, making possible social change in order to pursuit sustainability.

In a perspective where higher education assumes a leading role in preparing students and providing information and knowledge to achieve a just and sustainable society, education of all professionals would reflect on a new approach to learning and practice. In this context, "a college or university would operate as a fully integrated community that models social and biological sustainability itself and in its interdependence with local, regional and global communities" (Cortese 2003, p. 17). As students learn from everything around them, activities developed in higher education form a complex network of experience and learning. Thus, all parts of university system are fundamental to achieve transformative change (Cortese 2003).

Given this perspective, there is a clear need for universities to assume leadership positions, demonstrating practices that promote sustainability, instead of degrading environment, thus encouraging an educational process that stimulates a sustainable society (Lukman and Glavic 2007).

For Stephens et al. (2008), regarding sustainability, one of the main higher education institutions' roles is their potential as agents for society change. According to the authors, there are many different perspectives, perceptions, and expectations about the role, value, and potential of universities in society. However, considering that these perceptions may vary between different cultures and contexts, Stephens et al. (2008) present four general categories of perceptions about how higher education institutions can contribute to social transition toward sustainability.

First, *higher education can model sustainable practices for society.* Sustainable behavior must be present in campus itself, promoting sustainable practices and learning how it is possible to maximize sustainable behavior in society. Second, *it teaches students how to deal with complex problems* that are necessary to face challenges of sustainability and integration skills, synthesis, and systemic thinking about this theme. "Third, *higher education can conduct use-inspired, real-world problem-based research* that is targeted to address urgent sustainability challenges faced by society" (Stephens et al. 2008, p. 321). Finally, *higher education can promote and increase involvement among individuals and institutions*, both on and off campus, relocating universities as highly integrated agents and interconnected with other institutions of society and, therefore, as transdisciplinary institutions.

Contributing to this analysis, according to Amaral et al. (2015), in general terms, a sustainable university should teach the concept and philosophy of sustainable development to its students, but it is also fundamental to be able to conceive the concept within day to day of organizational management.

HEIs play a fundamental role in enhancing the creation and diffusion of sustainable thinking by being thought and opinion trainers. In order for this process to be possible, it is necessary for people involved in university activity development to serve as basis for knowledge dissemination and sustainable practice strengthening. It should be noted that there are still many challenges that need to be overcome in higher education, in terms of sustainable development, even considering advances already made (Leal Filho et al. 2015).

Considering sustainability challenges heterogeneity, as well as societal expectations, values, and cultures that impact higher education in different communities and regions around the world, Stephens et al. (2008) describe five specific issues. These are issues that include factors internal and external to the higher education system and provide a systematic approach to review challenges and opportunities regarding sustainability. *The five questions relate to (1) the dominant sustainability challenges of the region, (2) the financing structure and independence, (3) the institutional organization, (4) the extent of democratic processes, and (5) the communication and interaction with society* (Stephens et al. 2008, p. 323).

According to the authors, these five critical questions can help assess the potential and

limitations of higher education as a change agent for sustainability and can be explored in the context of any higher education institution or system around the world. In this context, identifying specific characteristics of HEI region can facilitate the design and implementation of new initiatives and new approaches, maximizing and accelerating potential of higher education in social change toward sustainability.

In this sense, it should be noted that higher education institutions are still important references for societies that shelter them and configure themselves as centers of production of knowledge and possibilities for solutions to the problems they experience. This way, they represent an opportunity to quality of life improvement and a place for individual training. Thus, what is done in it and how it performs, it can serve as a parameter for different society sectors (Sorrentino and Nascimento 2010) and in various themes related to sustainability.

Building and Educating: An Example of Knowledge Transfer Approach

The following study was carried out by Research Center of UNIFAAT University Center, located in the city of Atibaia, São Paulo, Brazil, seeking to demonstrate the importance of knowledge transfer aiming at sustainability. The case study was carried out at the sewage treatment plant (STP) of Bragança Paulista, São Paulo, Brazil, whose administrative building is certified by Leadership in Energy and Environmental Design (LEED). To obtain the data presented below, an interview was conducted with the technical manager of the institution that is responsible by the STP administration – São Paulo State Basic Sanitation Company (SABESP). Field visits previously scheduled and accompanied by the technician were also important to the data collection.

City of Bragança Paulista is located in the State of São Paulo and is part of the Bragantina region, which has undergone an intense process of industrialization and disorderly urban growth with diverse negative effects on the environment. It can be highlighted the impacts on water resources, considering that one of the main region characteristics is its abundance of water resources and that three of the four reservoirs that make up the Cantareira system find themselves in this region – (1) the Jaguary and Jacareí River reservoir, (2) the Cachoeira River reservoir, and (3) the Atibainha River reservoir. The Cantareira system provides water to São Paulo Metropolitan Area – SPMA (66% of SPMA consumption) – and Campinas Metropolitan Area, CMA (85% of CMA consumption), probably the largest urban and industrial centers in the country, and that find themselves in continuous conflict over water use (Machado 2014).

In this scenario of urban and industrial growth, various sectors of society must face the challenge of sustainability by proposing measures and developing programs that significantly reduce the environmental impact of its activities, in partnership with public power and civil society to improve life quality.

It is part of this challenge to promote actions, projects, programs, and research that can build and disseminate knowledge about sustainable development. Through this process, it will be possible the intervention of different social actors in the environment in which they live, aiming at achieving sustainability. For this, as mentioned by Castro and Pelicioni (2007), it is fundamental that those involved can clearly know the socio-environmental problems in a given reality, elucidate their causes, and determine the means to solve them.

In this context, educational process is essential, and it can be done in an articulated way, considering formal and nonformal education, involving universities, schools, communities, governmental and nongovernmental organizations, and companies, among other actors.

Thus, this study, carried out at Bragança Paulista STP, represents an example among the various learning spaces that can be used aiming at knowledge transfer to sustainable development. In this case, an analysis was made on how the STP physical space can be used as an educating element for environment conservation.

Bragança STP was a pilot project of the sanitation company and has the first certified green

building of SABESP. The area certified by the LEED seal is 19,322 m^2, of which 391 m^2 are built – the rest of the space is occupied by green areas. According to the certification rules, the construction meets sustainability requirements in six categories: space, rationalization of water use, energy efficiency, internal air quality, innovation, and design.

According to the study carried out at the STP, the main challenges for a construction based on the context of sustainable development are low availability of products and components that meet the requirements of LEED certification in the market, awareness and training of employees during the execution of daily activities, and absence of adequate sites for the disposal of construction waste in the region, relying only on recycling cooperatives to deal with the waste generated at the construction site in a proper way (Machado 2017).

The benefits identified during the research at the STP are related to the following factors: the architectural design privileges the natural lighting, and the double-height ceiling improves ventilation, avoiding the need to use air conditioning; 13,000 m^2 occupied by green areas preserve the riparian forest; the structure for collecting rainwater retains suspended materials, which are not carried to the point of discharge; paving is permeable and reduces heat island effects; alternative transportation for employees is encouraged with preferential seats for vehicles powered by alcohol and natural gas, bicycle, bicycle locker, and access ramps; the consumption of water and electricity is smart; the toilets have box coupled and double command and the taps count with automatic closing and flow restrictors; more efficient presence sensors, fluorescent lamps, and motor hoods are also used; during construction there was a preference to use materials produced regionally; and the estimation that a certified building can reduce solid waste emissions by up to 70%, drinking water use by 40%, CO_2 emissions from 33% to 39%, and electricity use by 24–50%.

Raising and knowing the benefits and challenges related to choosing a more sustainable posture in Bragança Paulista STP can help those directly and indirectly involved in the research to acquire and disseminate knowledge about sustainable development, as they delve into the analysis of different aspects related to this concept. From this perspective, it is worth highlighting that, regarding environmental education, Bragança Paulista STP already has a permanent program of visitation in its facilities.

In these activities, participants are sensitized about the water issue regarding the region and the importance of sewage treatment to maintain both life and environment quality. However, during the development of this work, it was noticed that elements related to sustainable development that target construction sector are little approached during these activities. Through an environmental education perspective, the awareness potential of these visits could be leveraged, once options for less impacting alternatives in this sector have great educational potential, such as the intelligent and efficient use of water and energy, the incentive to alternative transportation, and the natural ventilation and light improving environmental comfort with low impact.

From the case study development, it could be noted that benefits of sustainable construction go beyond the reduction of environmental impacts, making enterprise more efficient and, thus, collaborating to sustainability in a more wide perspective. However, some challenges are faced for its implementation, such as sensitizing society that sustainable construction can be an economically and environmentally viable alternative if it is developed in a planned way and if it considers the evaluation of all construction life cycle.

One of the connections between environmental education, knowledge transfer, and sustainable construction is that these spheres can create conditions for a critical ecological awareness and show that human beings and nature can coexist in a balanced way. The study in the STP made it possible to verify the benefits of sustainable construction. However, it was also observed that the LEED-certified administrative building is not exploited in its total capacity for environmental education and knowledge transfer regarding sustainable development. Sustainable

construction can be an important tool for education by encouraging a reflexive critical analysis of environmental problem, thus helping to minimize socio-environmental impacts.

The example of SABESP building case study was a practical way to demonstrate how sustainable construction can be an instrument for environmental education and for knowledge transfer with regard to sustainable development. The SABESP building has the most basic LEED certification available, and yet, it was possible to identify several important environmental aspects that it meets. They are aspects that depend much more on construction-conscious development than on financial resources. It demonstrates that lack of financial support is not an obstacle to sustainable construction. Therefore, the awareness of society is extremely important, and the lack of it is the main barrier to a sustainable future.

Final Considerations

According to Lukman and Glavic (2007), sustainable development principles represent one of the major challenges for the establishment of a better common future. They also remain a challenge at university level.

In this context, it is becoming increasingly clear that education and knowledge transfer related to sustainable development are essential if effective changes are to take place as regards how humans have interacted with environment. In this sense, it is expected that sustainability may be feasible now and in the future.

The sewage treatment plant case study (Bragança Paulista, São Paulo, Brazil) presented in this paper demonstrates that research and actions for sustainable development must also take place beyond the university campus and involve diverse institutions and social actors. Conducting this research provided the teachers and students involved to raise and develop knowledge about themes that contribute to sustainable development. On the other hand, it enabled the sewage treatment plant to know its potential in promoting knowledge transfer involving sustainability, regarding its administrative building, which is certified by LEED seal.

In view of the above, it can be mentioned that there are many efforts of higher education institutions in promotion of actions, projects, research, knowledge construction, teaching and learning processes, and management systems that enable a more inclusive society. But there are also many challenges to overcome, which are part of the process of understanding and consolidating HEIs' role for sustainable development. Such challenges must be overcome in a critical, reflective, participatory, and collaborative way, involving society as a whole, outside and within academic campus. In order to do so, the more knowledge about current environmental problem and its different perspectives are developed and shared, the closer society is to sustainability.

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Transformative Learning for Sustainability

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Definition

The theory and practice of sustainability education, while often transformative in intent, does not often draw from transformative learning scholarship. This chapter reviews the three approaches to transformative learning that facilitate micro level or individual change, meso level or transpersonal and institutional change, and macro level or social change. Sustainability education is most transformative when it addresses all three levels of change, in this case in higher education. At the macro level, it challenges the deepest structures of Western epistemology (ways of knowing and nature of truth), ontology (ways of being and nature of existence), cosmology (nature of the universe), and ethics (nature of moral values and conduct). Drawing from Karen Barad (2007), an onto-epistemological-ethic of relationality begins to transform the dualism, reductionism, mechanism, and anthropocentrism built into our knowledge systems. At the macro level, this can drives global approaches to technology, professional practices, and policy making. At the meso level, it can assist in cultural transformation of educational institutions toward a relational paradigm of sustainability, thereby enabling capacities to address pressing global issues and assist in achieving the Sustainable Development Goals (SDGs). At the micro level, transformative learning can guide curriculum and pedagogical

development that is consistent with relationality approaches to sustainability.

Introduction

It is clear to many educators and social innovators that the intractable issues we face in our current global system require a profound restructuring of educational systems, alongside other societal change. While sustainability education is often aimed at change, not all forms of learning and resulting change are transformative, particularly in higher education. As UNESCO (2014) suggests, educational institutions are straining at their edges to accommodate the necessary transdisciplinary approaches as well as moving toward a cosmology, ontology, epistemology, and ethics of relationality – all elements of a deep understanding of sustainability. Deep sustainability holds the potential to think in a different way about inclusivity, innovation, economics, safety, and equity, all elements of the SDGs.

While much has been written on sustainability in relation to habit change, organizational change, and change management, little has been informed by scholarship on transformative learning. Further, while sustainability initiatives assume an intention toward change, not many catalyze a deep transformation in the key operating assumptions that currently dominate in Western cultures. This is especially evident in higher education which, as large institutions are slow to change, despite their role in knowledge creation and dissemination.

This chapter describes the three dominant variants of transformative learning that address processes of change at the micro, meso, and macro levels. Transformative sustainability education (TSE) builds on micro, meso, and macro understandings but also moves beyond mechanist, scientist, dualist, and reductionist structures toward post-humanist ways of knowing and being and an onto-epistemology of relationality. By embracing a transformative process of deep sustainability, we will have the knowledge, skills, and predispositions to be able to withstand the coming decades of turbulence.

Concept of Transformation

The concept of transformation has been central to modern thinking, often considered the most complete or radical form of change. *Trans-form-ation* assumes that it is a change in form. *Trans* means to "go across" indicating the dynamic of "morphing" or moving from one shape to another. In other words, transformation involves a living process of structural change, not just a change in surface appearance or an evolutionary development.

The concept of transformation is part of a constellation of Enlightenment ideas, inferring freedom and emancipation from oppression in all its forms. The Modern Era in the West threw off the yokes of tradition, including feudal land holding, the divine right of kings, unquestioned obedience to the Church, and birth into an unchangeable social class. Over several 100 years, the West embraced the ideas of the Enlightenment, manifested in liberal democracy, private property, industrial capitalism, entrepreneurial commerce with a rise in the middle class, religious pluralism, urbanization, and class mobility. Change, not tradition, became pre-eminent.

Modernist ideas are implicit in transformative learning theorizing, including progressivism, rationalism, causality, autonomous individualism, and interventionism. Yet, some theorizing is attempting to struggle free of problematic aspects (Lange 2012, 2018) and the constructivist, humanist, and critical social theories in which these concepts are embedded (Williams 2018). This is most evident in Transformative Sustainability Education (Lange and O'Neil 2018).

Transformation Processes

Until recently, there have been three original variants of transformative learning theory, all founded on modernist precepts. Yet, transformative sustainability theorists are recasting these in new ways.

Micro Level Change

The first variant is called perspective transformation. Through his 1980s pioneering study on

women returning to community college, Jack Mezirow (1991) coined the term "transformative learning" within the field of adult education and lifelong learning. For Mezirow, transformative learning is *the* central task of adulthood, in that adults should be continuously challenging their inherited or uncritically assimilated beliefs systems. While higher education often leads to transformation, transformative learning is not a process explicitly embraced by higher education institutions.

Mezirow understood transformation as the rational process of assessing one's *meaning perspectives* or habits of mind. During a reflective process, most often in dialogue with others, adults can identify their personal paradigms and how these constrict their perceptions, limit their understandings of the world, and shape emotive responses. As adults rework their daily assumptions, the learning process is expected to yield perspectives that are more inclusive, discriminating, and permeable. In a defensive response, some individuals have a "hardening of the paradigms," and will attempt to vigorously apply their old ways of knowing, yielding rigid thought systems. Yet, the most an educator can do is invite people into the process. As a humanist, Mezirow believed that individuals would often rise to the challenge.

Assumptions that adults examine can be epistemic habits, sociolinguistic habits, psychological habits, moral-ethical habits, and/or aesthetic habits. The outcome of transformation is a "structural reorganization of the way a person looks at himself or herself," attaining the ability to think for themselves (Cranton 2005, p. 631). Autonomy of thought coheres with the central tenet of the Enlightenment which Kant (1983) understood as the emergence from self-imposed immaturity which relies on understandings derived from others. "Have courage to use your own understanding! – that is the motto of enlightenment" (p. 41). This epistemological shift is the *raison d'être* of the Modern era and, by extension, of transformative learning.

The process of transformative learning is considered best led by educators who can facilitate rational discourse. Within Habermasian conditions for clear and equal communication, learners can weigh the validity of their premises or truth claims within group dialogue. This process, however, challenges much of conventional pedagogy in higher education, where the professor is positioned as an expert who is a "sage on the stage" dispensing knowledge in trickle down manner. Transformative learning, rather, requires educators to respect the life experience and ideas that learners bring with them into the learning environment, making the educator a guide and co-learner in the discovery process of knowing.

Mezirow identified ten phases of transformative change that learners undergo, although these have been widely debated. The most research-confirmed phase is the disorienting dilemma. This refers to an unexpected event, person, or idea that cannot be understood within one's existing meaning framework. This may trigger the start of a transformative process to resolve this disorientation. Such a process usually involves self-examination, reflecting on the premises of their thought, seeking out people with shared experiences or viewpoints, exploring new ideas/roles/relationships, formulating a plan of action, experimenting with new ways of thinking and ways of being, and eventually integrating the new perspective into their lives. This process can be quite sudden (epochal) or gradual (incremental). Either way, if the transformative learning has reached the integration phase, it is typically irreversible.

One example of this transformative approach to sustainability education is seeking a change of mind or a consciousness change. For instance, Daloz et al. (1997) identify the habits of mind that enable people committed to sustainability to work effectively over the long haul. Robert Kegan (1994) discusses a constructive developmental theory of sequences, moving from adolescence third-order consciousness to a self-authoring fourth-order consciousness to a "trans-system" fifth-order consciousness. Education for shifting consciousness is also familiar among those educators working with Bateson's levels of consciousness. Another example is teaching systems thinking. The ability to think systemically is similar to Brookfield's (1987) description that "presupposes the development of critical thought – the

ability to recognize, question, and articulate the assumptions underlying one's own as well as others' thought and actions. Shifting from recognizing cause-effect thinking toward "integrated, interconnected, self-maintaining complexity" that understands how a system operates and the leverage points for change (Meadows 2008) manifests perspective transformation. Echoing Mezirow, Daloz (2004) suggests that this kind of transformative learning helps to nourish a semi-permeable self through a process of learning how we learn and by shifting our habits of mind.

As is evident, this theory is focused on the micro level of change, or rather individual change, one student at a time. It relies heavily on cognition and rationality rather than other ways of knowing. It is also progressive in assuming that adult development progresses toward increasingly optimal states, in this case, attaining autonomy of thought and a permeable self. While these elements are useful, they can also restrict the reach of change.

Nevertheless, much of sustainability education by default is focused on individual learning. Within a modernist understanding, citizens are understood as rational choice-makers who take an informed and active role in society by examining threats and possibilities, thereby building the collectivity of society. On this basis, sustainability educators expect that framing the issues in a compelling way, providing factual science, and creating a context for rational weighing of viewpoints will led to transformation and civic engagement.

However, this link between knowledge and action is not given. In response, sustainability educators complain about the despondency, narcissism, resistance, paralysis, or denial of the general public to research-based facts. Learners respond by pointing to the weight of larger problematic systems which dwarf the size and impact of individual efforts. Structures – economic, political, and cultural – seem to constrain meaningful change.

Yet, change at the individual level is vital. After higher education degrees, well-positioned change makers can act as champions of sustainability. The multiplication of individual efforts can also create movements of change, albeit sometimes slow and often frustrating.

Meso Level Change

The second variant of transformative learning emerges from analytical depth psychology and organizational transformation theory. Transpersonal psychology is distinct from mainline schools of psychology such as behaviorism, Freudian psychoanalysis, humanism, and analytical psychology. A general description and then an application within sustainability education will be discussed.

In this variant, transformation is considered "a fundamental change in one's personality involving conjointly the resolution of a personal dilemma and an expansion of consciousness resulting in greater personality integration" (Boyd 1989, p. 459). Discernment, not critical reflection, is the primary transformative process and the central work is soul work. For the most part, however, spirituality (distinct from religion but addressing the human spirit), philosophy, and consciousness studies have been marginalized in the Western academia, now in resurgence.

The goal of Jungian psychoanalysis is individuation toward wholeness of self. While the process is through individual self-exploration or small group exploration, it is transpersonal in impact by shifting symbols and archetypes that comprise collective narratives. It is also transpersonal in fostering a larger sense of self beyond the individual, in understanding profound connectedness to the rest of the living world, human and nonhuman. It moves beyond ego-based rationality to also engage emotional and symbolic content. This psychic content finds many avenues into consciousness, sometimes emerging through sleep-based or waking dreams, flashes of insight or vision, or through intuitive or imaginal processes sparked through arts and music-based modalities. In identifying archetypal motifs, learners engage the collective unconscious of humanity and thereby have access to levers of knowing and change. However, this process is often difficult as one must walk directly through grief, emotional pain, and layers of psychic protection.

As Clark and Dirkx (2000) suggest, Jungian theory also challenges the unitary, autonomous, coherent view of the modern self. It holds an

understanding of the self as plural, inherently conflicted, and often motivated by unconscious agendas. Transformative learning surfaces these inner conflicting elements in a search for resolution and thus assists in the integration of multiple facets of one's personality. While this process can be within a therapeutic process, it can be approached on a small group basis in the classroom (see Clark and Dirkx 2000), as long as the educator has done their own psychological work and is familiar with small group dynamics.

One exciting example of a transpersonal approach to transformative learning related to sustainability comes from O'Sullivan (1999). He suggests that we are not motivated and energized by rational ideas, but by the dream structures embedded in our collective psyche. As Jung has said: the dream drives the action (p. 3). The symbols of the modern western world are like mantras ringing in our ears, which normalize the consciousness that propagates the consumer-industrial culture, including positivity to unrestrained profit-making that is a variation of imperialism, industrialization as progress, and the desire to consume (p. 103).

These mythic structures are inculcated in schooling and higher education, including myths of: competition; merit; getting rich, rich lifestyles; achieving fame; survival of the fittest; self-interest; deserving the best; and getting as much for as little as you can. Further, advertising helps us to see consumer items as fulfilling our desires for identity, belonging, meaning, and respect. We come to believe that there will be scientific and technological fixes to the wicked problems we face as humanity. The distractions of entertainment and desire to accumulate experiences, largely through travel, further build these mythic structures. Modernity and alienation from the natural world have also led to an ecological blindness. This cultural programming will persist, O'Sullivan says, until there is a contrasting cosmological narrative with a vastly different ethic, challenging public enrapture to these mythic structures.

Drawing from the writing of cultural historian and ecotheologian Thomas Berry, O'Sullivan asserts that the human story cannot be considered apart from the Earth story. The central purpose of education should be the wellbeing of the Earth and the wellbeing of humans. For him, human habitation on the Earth needs to be reconstituted in harmony with the integral functioning of the planet. To attain these ethical imperatives, O'Sullivan suggests we need to move beyond the eras of conquest with its predator and dominator relations. O'Sullivan calls for an *ecozoic education* that uses *The Universe Story* (1992), a scientific and mytho-poetic narrative compiled by mathematical cosmologist Brian Swimme and Thomas Berry, to help learners locate themselves as humans within the much larger unfolding universe story.

Transpersonal psychology evolved into Integral theory through Ken Wilbur. O'Sullivan builds upon Integral theory as well as New Science (Capra 1996). Integralism utilizes the Universe Story to counter alienation and create a sense of relationality with all beings and elements in living evolution, inseparable in space and time. He suggests that education for Integral development understands the dynamic wholeness of the universe and of our consciousness. In this way, he describes transformation as occuring within ordered systems which have a normal band of fluctuation. However, when the system reaches a critical level of perturbation causing sufficient turbulence, the system transforms itself into a higher order, reordering itself into a new pattern. This "breakdown or transform" model of change is considered applicable to the processes we now see around us, calling for a biospheric politics with a much-expanded sense of time (Rifkin 1991).

The outcome of transformation is embedded in O'Sullivan's definition of transformative learning:

> transformative learning involves experiencing a deep, structural shift in basic premises of thought, feelings, and actions. It is a shift in consciousness that dramatically and permanently alters our way of being in the world. This shift includes our understanding of ourselves and our self-locations and our relationships with other humans and with the natural world. It also involves our understanding of power relations in interlocking structures of class, race, and gender, our body awareness, our visions

> of alternative approaches to living, and our sense of possibilities for social justice, peace and personal joy. (O'Sullivan et al. 2002, p. xvii)

Thus, the notion of the individual self gives way to relational matrix (1999, p. 225).

To enact a transformation process, he suggests that education should, first, name the historical moment we are in, particularly profound anthropocentrism, and then discuss how to live in a time of ongoing crisis and disaster including the responses of despair, grief, and loss. Second, education should help learners question the fundamental mythos, as a form of transformative critique. Third, an alternative and transformative vision to this dominant cultural form needs to be offered. To provide hope, concrete indicators of how current societal forms are being abandoned and new forms are being created illustrate ways forward. He names these stages as: survive, critique, and create, constituting deep cultural therapy.

In terms of higher education, O'Sullivan suggests that it can no longer be a closed process of knowledge accumulation; it must rise to the singular but complex challenge before us by shifting from teaching estrangement to teaching relationality. This requires incorporating a cosmic horizon, drawing from older wisdoms, celebrating life systems of Earth, interspecies awareness, and helping learners see their presence within a much larger historical process of geological evolution, human cultural development, and scientific-technological development. Finally, an ethic is needed that penetrates the current dream structure to dislocate the pre-eminence of corporate needs and White, patriarchial power, to build bioregional responsibility. It can inspire creativity and imagination for what can be. For O'Sullivan, the good and moral action is that which enhances, amplifies, or completes the natural processes of the Earth and universe toward differentiation, subjectivity, and community (p. 223).

One final example of this approach is Joanna Macy (1998) who also blends living systems theory, deep ecology, ancient wisdom traditions, and critical analyses of power. Through a Buddhist approach, she names all the psychological reasons for repression (pain, despair, distrust, guilt, being emotional, belief in separation, being morbid or unpatriotic, and powerlessness). She allows for an expression of grief for the Earth and all beings, as a way to reconnect to our basic humanity. By designing rituals and ceremonies that affirm interconnectedness, express despair, engage in evolutionary remembering, and consider sacred responsibilities, we can overcome deadening and "come back to life." She says that by acknowledging our pain and despair, we can avoid displacement beliefs that generate passivity, scapegoating, avoidance, and burnout. Macy and Seed have designed the Council of All Beings learning activity, various types of guided meditations, and a despair ritual that break through the current culture of estrangement.

The meso level is largely concerned with cultural change, as well as thinking frameworks, which can overcome the belief systems and ways of being that are unsustainable at their foundation.

Macro Level Change

The third variant emerges from Paulo Freire who focuses on change at the macro level, or rather social change. In the 1950s and 1960s, the brilliant Brazilian educator Freire developed a more collective and emancipatory form of literacy education for peasants and the urban poor. He was critical of schooling as "banking education" where teachers deposit knowledge into passive students who regurgitate this into products for evaluation, thereby developing compliant workers for an industrial, capitalist system. This critique still applies to much of higher education.

Freire developed an educational process for impoverished adults that used literacy as a way to analyze their difficult living conditions. Freire engaged learners by using the words they were learning to examine the political and economic conditions that created their poverty as well as discussing ways out of it. He called this transformative process, *conscientization*, a rising of consciousness that can break through the fatalism and culture of silence, particularly the belief they did not deserve better. He believed this fatalism was reinforced by education and the Church, replicating the favorable conditions for increasing wealth and power of the elites. Jane Thompson (1980) summarizes a core Freirean premise:

> There is no such thing as a neutral education process. Education either functions as an instrument which is used to facilitate the integration of generations into the logic of the present system and bring about conformity to it, or it becomes the 'practice of freedom', the means by which men and women deal critically with reality and discover how to participate in the transformation of their world. (p. 26)

Freire's work has inspired educators and education systems around the world, often known as critical pedagogy. Freirean transformative adult education critiques mainstream educational systems, recognizes the political nature of all education, and aims to transform all forms of oppression, particularly by race, class, and gender but along all axes of difference. But this form of education not only critiques, it offers a vision. . .in this case of a just and sustainable society. Critique and hope are held in dialectical tension.

For Freire, the social relations within a learning situation are integral to the learning process. He advocated that educators take up democratic relations, as co-learners with their learners, working together to "name the word" as they "name the world." In other words, as we language the world, we make the world. Rather than a prescriptive curriculum so often at the core of education systems, *praxis* is a pedagogy of the question. It disrupts taken-for-granted meanings, raises big questions, enables learners to reflect and know their social reality, and creates space to discuss ways of achieving change.

Another premise is that all educators have an ideological commitment, overt or covert. In this approach, educators are explicit about their ethical investment in social and environmental justice. This provides the opportunity for students to assess educator intentions. It flattens the status hierarchies generally present in higher education. Overall, it offers a deep experience of democracy.

Social change in this approach is not individual or incremental but it is at the collective level. Freire understood change as dialectical, through the conflict of contrasting ideas, which can break through into a third way. Assessing the logical outcomes of ideas can liberate learners to understand the consequences of certain practices and assess their collective interests. The threat for the state in this type of education is that it helps to build social movements for change. Freire was clear that education cannot "transform society by itself" – by intellectual reflection unrelated to significant movements in which social action concretely occurs. "Precisely because education is not the lever for the transformation of society, we are in danger of despair and of cynicism if we limit our struggle to the classroom. . .nevertheless transformation is an educational event" (p. 129). As Freire's process was so effective, he was exiled to Switzerland and later the USA. He published *Pedagogy of the Oppressed* (1970) and then experimented with his process in other continents, before returning to Brazil. He eventually was elected and held the position of Secretary of Education for São Paulo in the 1990s.

Freire's emancipatory form of transformative learning has been profoundly influential in Southern contexts, where poverty, oppression, and repression are more overt, and openness to humanist Marxism is less problematic. Yet, there have been important applications of Freire's ideas in Northern contexts too, including in the labor movement, antipoverty movement, immigrant and literacy education, women's movement, antiracism, and in other antioppression movements. Ira Shor used critical pedagogy within a New York-community college setting (1992). Myles Horton was inspired by Freire in the development of the Highlander Folk School. African American feminist bell hooks (1994), was profoundly influenced by Freire as she had experienced banking education in the Kentucky school system. Echoing Freire, she asserts that education should be a practice of freedom and hope. She enacted the ideas of: teaching as a sacred vocation, educational relations as one of liberating mutuality, and engaged pedagogy as necessary for transgressing and decolonizing cultural norms.

The "blind spots" in Freire's thinking have been well identified, including the elements of progressivism, interventionism, causality, and dualism (Mayo 2004). As well, new thinking about social change – beyond dialectical, functionalist, psychoanalytical, or social movement theories – has emerged, adding nuance to Freirean-inspired practices.

In terms of sustainability education, Freire's approach is present in the Ecopedagogy movement, promoted by Richard Kahn (2010) and Moacir Gadotti (2010) and very active in Latin America. Kahn's premise is that there is a crisis in environmental education, while very successful in fostering a socially active counterculture, new morality, new technologies, and institutional initiatives, a more radical and complex form of ecoliteracy is required to re-educate misunderstandings of basic environmental ideas, overcome the academic isolation of environmental education, and call out environmental literacy that is a "greenwash" (p. 9). More to the point, the matrix of domination and hyperindividualist anthropocentrism is ripe for radical reconstruction. This particular unsustainable system had a beginning and it will have an end.

Educational institutions can "bridge the politics of the academy. . .and alternative social institutions located in the public sphere. . ..with grassroots political organizing, capable of achieving social and ecological transformation" (Kahn 2010, pp. 18–22). Only by building the "extra- and intra-institutional foundations. . .can meaningful ecological policy, philosophy, and curricular frameworks" achieve the SDGs (p. 19). This discourse, then, links post-development and decolonization discourses to anti-oppression pedagogies, that all name the disruption of local cultures and economies, particularly Indigenous cultures, during the Modernist era (Esteva and Prakash 1998). Only resuscitating the cosmological dimension present in non-Western epistemologies, can vernacular forms of learning in specific places take hold once again, reinvigorating community self-sufficiency, equity, and environmental justice.

This level of change, therefore, is concerned with structural transformation – of economies, of technologies, of ideologies, of politics, and of institutions. The goal is a radically democratic sustainability politics and an empowered global civic culture, which is in a nascent form. This civic culture contests the transnational capitalist project that has taken us to the brink and helps reimagine hopeful trajectories for our planetary context.

Transformative Sustainability Education: Fostering an Ecology of Change

Processes of transformative learning and sustainability education need to struggle free of many embedded modernist assumptions around outcomes, measurement, and managerialism to focus on learning processes that best manifest deep transformation and sustainability. As is clear from the foregoing discussion, the core problematics revolve around the learning-action nexus and what constitutes transformation, if and how action can be fostered, and the nodes of action – individual/micro, cultural/meso, and structural/macro (Moyer et al. 2016).

A transformative sustainability education then needs to consider all the foregoing elements as an ecology of transformative learning (Lange 2015). Moreover, drawing from both modern physics and ancient wisdom traditions, there is a "relational shift" in ontology and epistemology occurring (Spretnak 2011). This shift points to the deeply relational nature of reality where all things are connected as an animate, living system, and interpenetrating whole. As Spretnak describes:

> . . .all entities in the natural world, including us, are thoroughly relational beings of great complexity, who are both composed of and nested within contextual networks of dynamic and reciprocal relationships. We are made entirely of relationships, as is the whole of the natural world. (p. 4)

Moving away from the colossal reconstructibility project of modernity and the Anthropocene Era will require a relational understanding of sustainability and deep transformation by questioning the ontological, epistemological, and cosmological roots of our societies (Lange 2018). "The environment," sustainability, and transformative learning are not objects to be acted upon or processes to be used instrumentally toward a predetermined end state. Humans are not independent rational agents acting upon the material world or on human worldviews to create transformation. Rather it is mutually learning and transforming into a new way of thinking and especially of being, within overlapping and expanding circles of human and nonhuman relations. As physicist Karen Barad (2007) suggests, the ethics of entanglement means that we are not

innocent, objective, and amoral bystanders. Neither are we the only actors in the universe. We are inherently entangled in a dynamic world, which makes ethical demands of us daily. It is this inseparability that challenges higher education which has been structured on reductionism, dualism, hierarchalism, and disciplinary specialization.

One example is Indigenous knowledge systems which "fundamentally challenge and transform our current global economic-cultural order" (Stewart-Harawira 2005; Williams 2018). While all human languages and cultures have been born of place (Battiste et al. 2005), the current structures are disembedded, as part of ongoing colonial invasion. Indigenous land-based onto-epistemology challenges the place-based education of sustainability educators. Unless the violence of settler societies and colonization is acknowledged and it becomes clear how settler colonial ideas pervade place-based education, then only a partial relational shift will evolve, as knowledge and identities are entangled (Williams 2018). Jeannette Armstrong (2006) frames active Indigeneity as "learning to live within the requirements of place" as in "sharing one skin." It is actively engaging with decolonization and encouraging transformative sustainability educators to teach about the Indigenous resurgence agenda which addresses wealth and power disparities as well as damage to the land (Williams 2018). In this way, then, many of the SDGs can begin to be addressed.

As Burns (2011), Widhalm (2011), and McNeil (2018) suggest, transformative sustainability education in higher education can be designed on ecological principles where the learning engagement is a living system itself. Transformative sustainability is making visible the underlying physical, social, ecological, political, and economic dynamics through the examination of new content, multiple perspectives, and local contexts. Place-based learning using an experiential and participatory pedagogy with self-balancing systems of feedback to constitute learning *as* sustainability (Burns 2011; Sterling 2009). Widhalm and McNeil, drawing from the work of Fritjof Capra (2004), have illustrated how to use living systems principles to design a pedagogy: through nested systems, networks, dynamic balance, cycles, flows, and development. Complexity theory also introduces the concepts of complexity, energy fields, distributed knowledge, bifurcation points, butterfly effects, and self-organizing systems to assist in understanding transformation (Lange 2012).

Blending the micro and meso levels of transformation can include : the role of *critical reflection* on premises within personal and cultural paradigms; *conscientization* about hegemonic discourses and the dominant mythos in society; *discernment* toward personality integration and a transpersonal consciousness; as well as *reenchantment* in locating oneself and the human story within the Earth story. As part of a new cosmology, this can create a vision of achievable alternatives to take us into a sustainable society.

In terms of creating macro or systemic change, Zivkovic (2017) discusses how creating a disequilibrium state, amplifying action, encouraging self-organization in communities, and using feedback and information, can build the adaptive capacity of communities. Further, the social innovation and community development literature defines the transformative process as *Scaling Deep, Scaling Out, and Scaling Up* (Riddell and Moore 2015; Westley and Antadze 2010). *Scaling Deep* is the process of impacting cultural roots by analyzing roots causes of particular issues, using systems thinking. Storytelling about successful innovations that contain big cultural ideas can shift beliefs and norms. *Scaling Out* refers to a deliberate replication of programs geographically and in numbers. What is replicated, though, are the principles that made the initial social innovation successful, which are then adapted in new contexts. *Scaling Up* is impacting the laws and policies that create barriers to sustainability practices. This is a process of political advocacy that can disrupt existing systems, link together community-level policy makers, redirect institutional resources, and precipitate the redesign of structures that currently constrain practice.

One ethical debate is whether transformative sustainability education is used as a tool for indoctrination. Transformative educators may have some intentions around outcome, but their intent should be to create conditions for inquiry with students

free to accept or reject content as part of democratic relations. There will always be resistance among some learners, particularly as the pedagogy will threaten the status quo. Further, the ultimate impact of transformative sustainability education is unknown and mysterious, as it taps many currents within an individual and a society, which cannot be shaped or controlled. Current thinking is that the process of educating/learning is itself the transformative element. While content can be chosen to disrupt understandings, the process of inquiry is the most transformative element. Nevertheless, capacity building in terms of skills, communicative abilities and linkages to social institutions and movements help support long-term transformative change. It becomes, then, "educating for the emergence of a different, possible world" (Gadotti 2010, p. 203).

Higher Education and Transformative Sustainability Education

University education emerged during feudalism, and public education emerged during early industrial capitalism. The structural core of formal or institutionalized education is to isolate disciplines, ages, sectors, and sites of learning. Locked into these siloed forms, educational institutions struggle to engage transformative sustainability education. A polyarchy of new forms of sustainability education are occurring in disparate noninstitutionalized sites. These sites offer visionary practices and highlight the restructuring required by educational systems, beyond their feudal and industrial roots.

Wals and Blewitt (2010) suggest that there have been three waves of sustainability in higher education. With the emergence of the environmental movement in the 1970s, the first wave was new programs and fields such as environmental engineering and environmental studies, but they were fit within existing empirical and theoretical reductionist frameworks. The second wave started in the 1990s with the proliferation of declarations by higher education institutions, such as the *Tallories Declaration*. While the rhetoric and rationales were helpful in profiling a sustainability agenda, it led to little concrete change in the mandate of universities. Rather this second wave focused on the operational level where campus greening sought to reduce ecological footprints.

Curriculum and pedagogical change at the university level have proven resistant to change. First attempts included individual professors infusing sustainability content into existing courses, but this has resulted in containment and marginalization. Those that have taken up the role of sustainability champions on campus have faced many barriers: contestations and vagueness around the concept of sustainability and its relationship to existing domains of knowledge; seeing sustainability as an impositional agenda; the lack of knowledge and skill around sustainability; difficulty speaking outside of disciplinary language; disciplinary silos with epistemic boundaries and legitimated methodological traditions with established reward systems; the structure of career tracks that shape university programs; and modern administrative governance and bureaucratic logics. Furthermore, regarding pedagogy, there is little agreement on what constitutes sustainability competencies (Sterling et al. 2017).

One mandate of universities and other higher education institutions is knowledge creation, knowledge dissemination, and addressing real-world issues. However, such real-world issues have proven to be *wicked problems* – complex social policy problems that cannot be definitely described, do not have clear solutions, and are rife with multi-causal factors, conflicting goals, and unforeseen consequences (Zivkovic 2017). Yet, there is a call for graduates who have sustainability knowledge and leadership capacity and who can act as decision makers and change agents around sustainability (Sterling et al. 2017). UNESCO (2014) has become quite pointed in its assessments charging that "the global transformation of higher education towards sustainable development has yet to occur" (p. 31). The former Director-General of UNESCO, Irina Bokova (2015), insists that re-envisioning education must parallel the deep transformation occurring in societies. She calls for new forms of education as well as systemic approaches to curricular change and capacity-building, to address global justice and sustainability solidarity.

There is now a polyarchy of learning edges within and outside the university. Groups of academics have hosted cross-fertilizing peer dialogue on their campuses to explore systemic and relational thinking. Cross-campus spaces have also developed where transdisciplinary learning is supported as a form of professional learning. This professional learning is invitational and participatory, not impositional and predetermined (Moore 2005).

Research is slowly become interdisciplinary, and even transdisciplinary, to address wicked problems. Research questions are becoming highly integrative, beyond any one discipline and their fragmentary knowledge. Some programs are eliminating disciplinary units and letting the real-world problems drive the curriculum and the need for disciplinary thinking (Redman and Wiek 2013). University activism has always played a major role in social change and linkages between classrooms, community advocacy and social movements are natural alliances for fostering awareness, learning, and action. Kahane (2012) suggests that transformative scenario planning is a strategic tool that can assist organizations moving beyond existing logics by focusing on: systemic diagnosis of context by a range of players who respect each other but may not agree; denser connectivities so that networks create reinforcing feedback systems, and learning so that personal values and identity are connected to the big issues around us. Tried in post-apartheid South Africa, the process of developing plausible scenarios together diverse stakeholders can avoid common pitfalls and more consciously led to transformative action. New vocabularies and language are also emerging to encapsulate new ways of being, thinking, and acting, itself a process of decolonizing from modernity (Kimmerer 2015; Lange 2017). Many higher education educators are reorganizing higher education programs outside of the university auspices in more flexible arrangements.

Final Remarks

In sum, we are currently in transition between the modern and postmodern epochs, constituted by paradigm shifts in multiple science and social science fields. This shift is every bit as significant as the shift from the medieval to modern (Best and Kellner 2001). Premodern (traditional/non-Western), modern, and postmodern ideas all currently coexist within collective and individual belief systems.

With this in mind, Selby and Kagawa (2015) suggest that the key elements of transformative sustainability education include: education that interrogates the drivers of the unsustainability crisis; education that challenges underlying assumptions and paradigms; education that is integrated with social action and is able to scale innovations more broadly into society; education that taps learning modalities outside of what is commonly accepted; learning that is anticipatory and creative by manifesting a vision of what is possible; education that is inter- and trans-disciplinary; education that is entangled and immersed in the natural world and interactive with physical elements and species; learning that is localized to and respectful of land; and learning that walks out of four classroom walls into many spaces and places. Fostering transformative learning at micro, meso, and macro levels, creating an educational space that is predicated on ecological principles and mimics a living system, challenging current epistemological, ontological and ethical systems, and offering the vision of an ontology of relationality are the deepest and strongest forms of transformative sustainability education.

This is the largest crisis in the legitimacy of higher education in 500 years, but with a polyarchy of transformative research, education, and action across many disciplines, the learning-action nexus can be bridged into multiscalar relationships that become places of real change. Such transformative sustainability education can eventually manifest in life-giving societies, achieving the goals of sustainability.

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Transformative Pedagogies for Sustainable Development

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Definition

Transformative pedagogies for sustainable development encourage learners to change the direction of development that seems to be inevitable by enhancing their awareness, understanding of complexities, empathy, compassion and empowerment.

New Ideal of the Good Life Is Needed

In a new geologic epoch – the Anthropocene epoch – humankind is the biggest individual determiner of the future of planet Earth, which means that the future is in the hands of humans more than ever before (Crutzen 2002). In other words, the effect of humans on the atmosphere, oceans, and nature is great enough to leave permanent impacts (Rocktström et al. 2009). The species *Homo sapiens* is destroying the natural systems that maintain all life (Ripple et al. 2018).

Our children will live in a world where wild areas are reduced, where there are fewer animal and plant species, where fewer areas are available for food production, and where natural resources are declining and the climate is more volatile (Marsh 1965; Ward and Dubos 1972; Budowski 1984; Ehrlich et al. 2012; Wiedmann et al. 2015; United Nations 2015; Ripple et al. 2018). Thus, holistic societal change is needed to create safe and fair operating space for humanity. These changes are among the biggest learning challenges facing humankind (Åhlberg et al. 2014).

In the history of mankind, a fatalistic way of thinking has been replaced with a new understanding. People have started to understand that they can be creators of their common future. Therefore, two kinds of future strategies have been developed. *Political strategy* emphasizes innovation and technological progress that is regulated by decision-makers. *Pedagogical strategy* is based on the relevance of identities, values, and ethical frameworks. This strategy is emphasized, for example, by behavioral economics, behavioral sciences, and education sciences (Hämäläinen 2015, 1023).

The World Commission on Environment and Development presented *sustainable development* as a model of holistic social change (WCED 1987, 46). Fundamentally sustainable development is about the transformation of basic aspects of the present ideal of material well-being to protect the

natural systems that maintain human and non-human life (Baker 2006). In its deepest sense, this means that the main goal of learning is seeing things differently instead of doing things better or even doing better things (Bateson 1972; Sterling 2010).

Later, quality of social change is described by the Agenda 2030 action plan. It came into effect in the beginning of 2016. The 17 universally accepted goals and 169 targets at its core apply equally to all countries (United Nations 2016). The main purpose of the Agenda 2030 is noble: "We resolve, between now and 2030, to end poverty and hunger everywhere; to combat inequalities within and among countries; to build peaceful, just and inclusive societies; to protect human rights and promote gender equality and the empowerment of women and girls; and to ensure the lasting protection of the planet and its natural resources" (United Nations 2015).

Transformative pedagogies for sustainable development ask how we human beings could, as decision-makers and citizens, change the direction of development that seems to be inevitable. How does learning transform humans and human-environment relationships? How could students integrate personal transformation pathways in attempts to shape material and social changes? Which social factors could drive humanity to move away from unsustainability? How can societal transformations be accelerated toward sustainable development goals?

Implementation of Agenda 2030: From Behavioral Changes to Social Change

Even if humankind face great challenges, we are able to overcome them. Societies are becoming more affluent. People are more prosperous than ever, and the amount of available information is enormous. Freeing citizens from extreme poverty is no longer the main object of national governments. Therefore, broader examination of well-being enables recognizing the heart of progress. Education as a social process and function is in vain until we define the ideal of society we have in mind (Dewey 1916).

There is a common vision concerning the notions of what is good life and progress in society. People from different background agree that peace is better than war and equal rights are better than discrimination. We also think that happiness is better than misery and opportunities to enjoy family, friends, culture, and nature are crucial in life (Pinker 2018). In other words, progress and a better future are clearly defined as a shared vision in Agenda 2030 (United Nations 2015). It pursues a peaceful, sustainable society, comprised of more personally fulfilled people, making full use of their potential (Fadel et al. 2015, 7). The challenge is how to make it happen. How do we reach these common goals?

The present socially constructed beliefs and assumptions about the good life consist of anthropocentrism, individualism, unlimited growth, and technological progress (Glasser 2018). Traditional Western logic is based on linear thinking, where systemic views are not common. A common assumption is that the future can be predicted by examining the past and present and identifying the cause-to-effect relationships between them. This is manifested by a reductionist and simplifying discourse, in which there is no attempt to recognize the interconnection of different parts (Ackoff and Rovin 2003). A need for simplification is easy to understand because current life is more complex than before and people want to have the feeling of good life management in their everyday lives.

It is necessary to question the present socially constructed beliefs and assumptions about the good life because it reproduces society and culture with the harmful *metanarrative* (Fadel et al. 2015, 98–99). From the systems thinking point of view, there are three basic dimensions of progress, and a hierarchy exists between these dimensions. The sustainability promoting metanarrative is based on the fact that without well-functioning nature, there can be no society because humankind is dependent on thriving ecosystems and the sustainable use of natural resources such as fertile soil, crop pollination, water purification, disease control, and climate control. Without a society, there can be no societal functions, including an economy. The solid base of society is built on human

rights, social justice, and dignity. The good life on the finite planet Earth is not possible without an efficient economy, which is necessary to fulfil the basic needs of people (Giddings et al. 2002; Hediger 1999; Ott 2003; Salonen and Konkka 2015).

Transformative pedagogies can be a tool that leads to societal transformation that underlines human solidarity and an expanding moral circle that includes people, animals, plants, and life-supporting ecosystems as well as the abiotic natural resources of the planet Earth. This is not possible to achieve without integrated transdisciplinary heuristics that combine social, natural, behavioral, and philosophic points of view (Salonen and Åhlberg 2012). Sustainability requires changes in worldviews, ways of thinking, well-being paradigms, and life orientations (Table 1). As a result of self-reflection, it could be found that the best experiences of life are rarely related to consumer goods. Consumption patterns are often driven by wants, not needs. Participation and belonging make us feel good. This kind of social capital can be increased without negative ecological effects. Knowledge, self-expression, freedom, affection, and participation can grow forever without any planetary boundaries (Lehtonen et al. 2018).

An example from the late fifteenth century helps us to identify what kind of social change is needed in practice. The principles of sustainable development were a reality among sheep herders in Iceland then. They noticed that overcrowding led to soil depletion and erosion. The Icelandic sheep herders had recognized the value of fertile soil as an indispensable prerequisite for their business. For this reason, they decided to unite and estimate the limit to growth in their business and found that the speed of recovery of the pastureland determined the limit of their activity. In practical terms, this was the number of sheep on the slope of a mountain and the fair sharing of sheep between the herders. Subsequently, the sheep herder community safeguarded the vitality of nature in order to ensure the material wealth of the community. The sheep herders adopted a more holistic way of thinking. They gradually changed their life orientation from individual to collective. They also decided to include in their moral circle the whole community and the whole ecosystems on the island, more than only herders' families. This was a concrete path toward full humanness and planetary responsibility in the late fifteenth century in Iceland.

Implementation of Agenda 2030 requires determined efforts at global, national, and local levels. It also involves a range of open questions and information needs (Odlekop et al. 2016). The Government of Finland aims to achieve the sustainable development goals of Agenda 2030 by the Society's Commitment to Sustainable Development (SCSD). The action plan is closely linked to another Government cornerstone project, the formulation of Finland's development policy. SCSD is an instrument produced by the Prime Minister's Office for implementing the Agenda 2030. According to the vision of SCSD "in 2050, every person in Finland will be a valuable member of society. Finland will be an affluent society that lays the foundation for sustainability and provides its citizens, communities and companies with the conditions they

Transformative Pedagogies for Sustainable Development, Table 1 Principles of change to achieve a sustainable future in the Anthropocene epoch. A path toward full humanness and planetary responsibility by expanding humans' worldview, way of thinking, well-being paradigm, life orientation, and moral circle from left to right. (Adapted from Salonen and Ålhberg (2012, 22))

Worldview	Self-centered			Human-centered		Life-centered		Ecosystem-centered	
Way of thinking	Atomistic thinking					Systems thinking			
Well-being paradigm	Accumulation of material goods					Harmony, coherence, consciousness			
Life orientation	Individual			Collective		Planetary			
Moral circle	I	My family	Friends and relatives	My nation	All people	Human beings and animals	Human beings, animals, and plants	Ecosystems	Planet Earth

need to operate sustainably. The carrying capacity of nature is not exceeded and natural resources are used in a sustainable manner. Finland will promote peace, equality and justice, and offer practical and sustainable solutions to the world's problems." To make the vision a reality, Finland has focused on achieving the following eights objectives (Lyytimäki et al. 2016; Commission on Sustainable Development 2016):

1. Equal prospects for health, education, and employment
2. Equal opportunities for all citizens to influence their own lives and common issues
3. Improving the productivity, profitability, and quality of work
4. Supporting an active civil society
5. A carbon-neutral society by the year 2050
6. A resource-wise economy and socially responsible business operations
7. Lifestyles based on nonmaterial consumption and services
8. Decision-making that respects nature

SCSD serves as a long-term framework and instrument of policy coherence for the strategy and program work of different administrative sectors. Every single Finn can make a public commitment on a digital platform. Moreover, hundreds of measurable and public commitments are already made by companies, municipalities, educational institutions, and nongovernmental organizations (Lepuschitz 2014). These commitments transform the whole society toward a more sustainable future (https://sitoumus2050.fi/). However, transformative pedagogies are needed in mainstreaming of sustainable development, and this requires adjustment of the values and attitudes of citizens (Commission on Sustainable Development 2016).

Toward Transformative Pedagogies for Sustainable Development

Pedagogical strategy for human development refers to human growth and education in theory and practice (Hämäläinen 2012, 4). Paul Natorp claimed that all pedagogy should be social (Natorp 1920). This kind of society-oriented pedagogy can be identified as *social pedagogy*, which is based on the large-scale and holistic theory of human development. A human being is considered as a member of society and of different kinds of communities – a group of people with responsibilities for each other (Hämäläinen 2003, 73).

Social pedagogy emphasizes holism. It asks what the full potential of the human being is in the context of society and how the relationship between individuals and society should be organized. It focuses specifically on the social preconditions for individual development and to opportunities to promote people's growth into active citizenship and social responsibility while still fulfilling personal interests and opportunities (Hämäläinen 2015, 1028). Thus, social pedagogy is about a general rather than special theory of education. It addresses opportunities to contribute to social life, welfare, and human development (Hämäläinen 1989, 128; 2003, 71; 2012, 12–13).

Social pedagogy is an example of a pedagogy that focuses on changing society (Hämäläinen 2012, 9). It deals with fundamental questions of societal order, human development, and citizenship education, and it promotes understanding ourselves as human beings (the human domain) and moral actors (the ethical domain). In the Anthropocene epoch, however, it is also important to understand human beings as a part of nature. *Transformative pedagogies for a sustainable development* transform understanding and conceptions about the interdependence of humans and nature (Laininen 2018). These three overlapping domains together – human, ethics, and nature – can promote human flourishing and a sustainable future when they are addressed simultaneously (Ehrenfeld 2008, 58–59). Therefore, truly transformative pedagogies not only focus on human self-awareness but also on deep social-ecological transformations in which people define themselves as a part of the surrounding social-ecological reality in harmony (Åhlberg et al. 2014; Salonen and Bardy 2015; Salonen and Konkka 2015).

Martha Rogers (1994) proposes five dimensions for transformative pedagogies:

(a) The cognitive dimension relates to knowledge and rational thinking.
(b) The affective dimension relates to a combination of emotions and knowledge.
(c) The existential dimension means that learners question their own values and ways of life and begin to rebuild perceptions of themselves.
(d) Empowerment refers to responsibility, engaging and redirecting life.
(e) Action includes making new choices on a personal, communal, and political level.

Transformative pedagogies lead to a holistic worldview (Laininen 2018) because they are based on the epistemic approach to learning (Bateson 1972; Sterling 2010). A holistic worldview together with systems thinking and ethics can be a key driver of sustainability in society. The ethical domain of transformative pedagogies is about extending the moral circle to include the entire social-ecological reality. The eco-social approach to education crystallizes into the adoption of a systemic worldview – the extension of the moral circle to cover all human beings, animals, plants, and abiotic parts of nature as presented in Table 1. I could start to ask, for example, what chain of people, raw materials, and power plants I have connected myself to by turning on the lights in a room. Each everyday choice maintains the system to which it connects citizens (Åhlberg et al. 2014).

Human freedoms and responsibilities are, subsequently, based on the dependence on nature and on other people. To achieve this, the moral circle should, firstly, cover ecological issues on which human beings are dependent and, secondly, social issues to secure the prerequisites for human rights and dignity. Under these conditions, it is possible to create a sustainable economy that fulfils the basic needs of all people on Earth. When living on a finite planet, it can be asked whether the best measure for our generation's progress is to ensure as much freedom for future generations as we currently enjoy (Sen 2009, 250–252). In order to achieve this, it is important to understand that without an ecological foundation, no human community can exist and, without the human community, there can be no economy. Therefore, all the challenges related to humanity boil down to ecological and social origins, as the economy is an eco-social process (Lehtonen et al. 2018; Åhlberg et al. 2014; Salonen and Konkka 2015).

Every interpretation of the surrounding reality is a result of social construction (Berger and Luckmann 1966; Searle 2010; Hacking 2000). However, even the best social construction is unfinished. Therefore, we human beings need each other to question our interpretations, paradigms, and way of thinking. Interaction and imagination help people to perceive the weaknesses of their worldview. Correction of them requires humility. Changing the unfinished worldview and the current unsustainable metanarrative requires epistemic learning, which could transform our way of thinking so that we are able to see the world around us differently (Tables 1 and 2).

Transformative pedagogies include possibilities for a dramatic change in thinking and behavior. Epistemic learning does not demand learners to do things better or even doing better things. It asks people to see the world around them differently. It can permanently reform learners' consciousness and change their way of being in the world. A possible shift "involves our understanding of relations of power in interlocking structures of class, race, and gender; our body-awarenesses, our visions of alternative approaches to living; and our sense of possibilities for social justice and peace and personal joy" (O'Sullivan et al. 2002, xvii).

These fundamental changes start with individuals and their change of attitudes, behavior, and

Transformative Pedagogies for Sustainable Development, Table 2 Developing of transformative pedagogy. Learning approaches, pedagogies, and goals to achieve a sustainable future (Bateson 1972; Sterling 2010)

	Way of learning	Goal of learning
Cognition	Conformative pedagogy	Doing things better
Metacognition	Reformative pedagogy	Doing better things
Epistemic learning	Transformative pedagogy	Seeing things differently

lifestyle. The reflection on transformative action points to the importance of community. In a physically, virtually, socially, politically, or culturally defined community, learners find causes that concern them both individually and collectively. It evokes the lifelong learning perspective recognizing nonformal and informal learning throughout the life of an individual. Therefore, transformative actions for sustainability can also be seen as an example of active citizenship (UNESCO 2019, 4–5).

A sustainable future is possible. In the Anthropocene epoch, humankind needs transformative pedagogies with *full humanness* as a goal. Then human beings can start becoming a part of a bigger story – metanarrative – that is a universal and equal story of a future consisting of peace and dignity (Siirilä et al. 2018). In order to reach this noble goal, transformative pedagogies for sustainable development should be embedded in all subjects in all curricula (Stough et al. 2017).

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Transformative Responses to Sustainability

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Changing Social Structure and Cultural Patterns

Our planet is as closed a system as a spaceship (Boulding 1966). A systemic entity, such as a planet, society, city, person, language, car, or telephone, is formed of the components it consists of and interactions between these components. A system maintains its existence through the interaction of its components (Bertalanffy 1968; Bunge 1979; Mingers 2006).

In a new geologic era – the era of Anthropocene – the spaceship Earth is in human hands (Crutzen 2002) because the human pursuit of the good life permanently changes the socio-ecological system on which our everyday life is fully dependent (Figueres et al. 2017; Ripple et al. 2017; Steffen et al. 2015). 1300 scientists from

95 countries concluded in 2005: "human activity is putting such a strain on the natural functions of Earth that the ability of the planet's ecosystems to sustain future generations can no longer be taken for granted" (Millennium Ecosystem Assessment 2005).

The question is what will intelligent, forward-thinking, and ethical human beings do who have better than ever access to data, solid historical evidence, and rich knowledge about future trends? If we really want to start seriously addressing complex social and environmental challenges, we need to think in terms of systems, and we must overcome the reductionist perspective and adopt a transformative orientation (Senge 1990):

> From an early age we are taught to break apart problems, to fragment the world. This apparently makes complex tasks and subjects more manageable, but we pay a hidden, enormous price. We can no longer see the consequences of our actions: we lose our intrinsic sense of connection to a larger whole. (Senge 1990, p. 3)

Transformative responses refer to social change. Social change is the alteration of social structure and cultural patterns through time (Harper and Leicht 2016, p. 5). The role of innovation and technological progress has often been emphasized in social change. Scholars in sustainability science and behavioral economics have also underlined the relevance of an ethical framework in the transforming process.

Great changes are possible. Humankind has already managed to stop global ozone depletion. We have almost doubled our life spans in a short period. Moreover, we have created a universal educational system and medical care. We also know what to do next. United Nations Agenda 2030 is a roadmap to human dignity by 2030. It is intended to end poverty, transform all lives, and protect the planet (UNEP 2014; United Nations 2014, 2015). The needed transforming process is dependent on both social structures and the behavioral changes of citizens.

Consumption habits in the wealthiest countries are the key to sustainability. The consumption of the world's most prosperous fifth (1.4 billion people) accounts for more than 80% of the use of natural resources and emitted pollution. This is 60 times more than the poorest fifth in the world. Therefore, even relatively small behavioral changes of citizens living in affluent welfare societies can effectively reduce the use of natural resources and combat climate change on a global level (Munasinghe 2014, p. 260).

Does higher education only reproduce the dominant way of living or does it offer transformative responses to society? This is a crucial question because universities can be a major contributor to unsustainability if they only reproduce the dominant mainstream culture (Orr 2004; Wals 2010). The main challenge for education is what do we need more and what less to have a good life?

A Transformative Higher Education Institution and Social Change

Transformative learning challenges the core assumptions and values that we as a society hold (Mezirow 1978; Cranton 2006; Howlett et al. 2016). Transformation in higher education refers to "a process of questioning and redefining one's frames of reference, experiences and assumptions to generate new meanings and new visions of future" (Leal Filho et al. 2018, p. 289). Sustainability promoting universities embrace pedagogies that educate students to become critical and reflective thinkers and practitioners (Howlett et al. 2016, pp. 316–317). Therefore transformative learning can even entail changes of worldviews (Sipos et al. 2008).

Transformative orientations lead to a holistic worldview (Laininen 2018). A holistic worldview together with systems thinking is a key driver of sustainability. This is a reason why transformative higher education institutions are interdisciplinary institutions. In practical terms, the interdisciplinarity approach means that transformative responses to sustainability is not possible without considering the interconnectedness of psychological, social, economic, and natural systems, for example, like this:

(a) According to the *psychological evidence*, we know that, in overdeveloping countries, mass

consumption leads to anxiety. Increased opportunities to spend more cause an inability to enjoy things obtained with money.

(b) According to the *philosophical evidence*, we know that after meeting basic human needs (water, food, clothes, shelter, energy, healthcare, and education), it is difficult to increase well-being by focusing mainly on material things.

(c) According to the *economic evidence*, we know that more sharing, cooperatives, and local economies are possible.

(d) According to the evidence from *social sciences*, we understand that the chances of having a good life are threatened by increasing inequality.

(e) According to the *ecological evidence*, it is not clear that future generations will have the same or better possibilities in their life as we enjoy.

Sustainable universities serve as a model of dignity and environmental stewardship (Sterling et al. 2013). This challenges the strategy, the management, and organizational culture of the higher education institution (Table 1). In the end, institutions could be forerunners in transformative responses to sustainability in society. In order to reach this level, collaboration, networking, and a strong impact on society are emphasized. The impact includes both local and global dimensions – planetary well-being. The institution is dynamic and forward looking. Trust and commitment hold people together there (Cameron and Quinn 2011).

By identifying connections and interactions between different things and phenomena, we can end up with decisions and policies both building sustainability in society and enhancing the well-being of citizens. This calls for holistic and empowering approaches to research, learning, and teaching, which reject the traditional cultural dualism and segregation. This demands educators to focus more on critical thinking, systems thinking, and enriching communication. What we also need is developing of higher-order skills such as logical thinking, analyzing, synthesizing, inferring, deducting, inducting, and thinking hypothetically. Most of all, this means that we need to think in terms of systems.

Transformative Responses to Sustainability, Table 1 Comparing higher education institutions: reproducing the dominant society to offering transformative responses to a society

	Higher education institution reproduces the dominant mainstreaming society	Higher education institution offers transformative responses to a society
Strategy	Thinking in silos and disciplines are emphasized. Institution maintains the dominant way of thinking in a society	Institution offers transformative responses to a society. Interdisciplinary approach is emphasized
Management	Management is based on control of individuals and their performance. Procedures and rules govern what people do	Management is based on common values and cohesion. Collaboration, networking, and strong impact to planetary Well-being are emphasized
Organizational culture	Institution is hierarchical. Activities are based only on local laws. Formal rules and policies hold people together. Stability is emphasized	Institution is dynamic and forward looking. Individual initiative and freedom are encouraged. Trust and commitment hold people together

Systems Thinking as a Driver of Transformative Responses

Systematically thinking people perceive the world as a systemic whole. Everything is connected. Some connections are distant and weak, others are immediate and strong, but the essential idea is that the connections and interactions guide the way people see the world. The worldview of these

people replaces an atomistic worldview in which a system can be understood by the sum of its parts. Instead, everything is a part of a larger whole and the connections between components are non-linear. This approach generates goal-oriented activities where the importance of the goal is emphasized, but the details remain in the background (De Rosnay 1979).

Systems thinking may help us to question our paradigms and worldviews. Without systems thinking, it is difficult to understand that there can be no society without a well-functioning nature. It is also evident that without a society there can be no societal functions, including an economy. The solid base of society is built on human rights, social justice, and dignity. The good life on the finite planet Earth with population growth is not possible without a robust economy. Without an efficient economy, it is not possible to fulfil the basic needs of people. However, no economy is possible in the absence of thriving natural ecosystems and people (Giddings et al. 2002; Hediger 1999; Ott 2003; Salonen and Konkka 2015; Max-Neef 2010). Thus, economy has no intrinsic value but is an instrument for human well-being. The human being is fully dependent on thriving ecosystems and the sustainable use of natural resources such as fertile soil, crop pollination, water purification, disease control, and climate control.

A systems approach is a powerful tool for creating transformative policies and strategies in society. A holistic, systemic, and integrative interpretation of the reality around us will not only help our everyday choices but will also help us to see bigger picture in responsible decision-making. This approach helps to reveal connections between parts that make a larger whole. It offers a way of seeing that there is a citizen in a house, the house is located in a town, the town is in a society, and the society is part of Earth. The systems approach may help, for instance, to recognize that it is economically questionable to have extremely low prices for unhealthy food. Diseases linked to overweight increase the burden on the health sector in society. They cause more premature deaths than malnutrition in our world (Lim et al. 2012). Instead, healthy diets save resources and improve the quality of life. For example, locally produced organic plant-based food has multiple benefits for citizens, society, and the planet because it supports local farmers and entrepreneurs, promotes public health, maintains biodiversity, and helps establish global food security (Salonen et al. 2014; Helne and Salonen 2016).

Connections between different components of human well-being can open a new way of thinking. For example, students who can see greenery out of their classroom windows do better than those who cannot (Matsuoka 2010), and patients are cured faster in a hospital room with a green view (Ulrich 1984). Moreover, people walking from A to B on a tree-lined path alongside a river were systematically happier than those who took the same trip via an underground tunnel system (Nisbet and Zelenski 2011), and those who live in walkable neighborhoods have been found to be significantly more likely to feel that they belong to their community than those in car-dependent suburbs (Leyden 2003).

According to John Dewey, "the conception of education as a social process and function is in vain until we define the ideal of society we have in mind" (Dewey 1916). Next we will envision some transformations towards sustainable society.

Visioning, Policy-Making, and Building a Sustainable Society

A basis of *standard of living* is accumulation of wealth. Accumulation of wealth is based on economic growth. Economic growth is often pushed by decisions about never ending *desires and wants* of citizens. A shopper who shops only to meet her or his *needs* – that are universal ends for the good life – poses danger to economic growth. However, permanent economic growth is not possible because "the economy is a sub-system of a larger and finite system, the biosphere" (Max-Neef 2010, p. 204; also Matutinovic et al. 2016). Planetary boundaries (Rockström et al. 2009) refer to an importance of identifying *basic needs* of human beings.

In many societies, the amount of money and time spent on meeting the basic needs of citizens

have fallen dramatically over the last few decades (Jansson 2011). When it is easy to fulfill the basic needs of everyday life, people tend to focus more on nonmaterial goals in life (Inglehart 1977; Jebb et al. 2018). In Shalom Schwartz's value theory, such a change in values means shifting from self-enhancement to self-transcendence (Schwartz 1992). According to Abraham Maslow (2011, p. 179) that kind of *full humanness* occurs as altruism, belonging, and social cohesion. This shift from getting a better and better standard of living to having greater and greater life satisfaction and happiness is linked to the question of sufficiency and ethics. As John Maynard Keynes put it: "when accumulation of wealth is no longer of high social importance, there will be great changes in the code of morals" (Keynes 1932).

The elements of human flourishing are non-material. These elements enhance *quality of life* and they can increase forever. When citizens shift from the material goals of life (standard of living) towards softer post-material values (quality of life), wide-ranging effects on citizenship, society, and the common future of humankind may appear. This is a strong and fundamental response to sustainability in an affluent society (Table 2). Thus, a fundamental question for policy-making is whether we should focus more on *quality of life* or on *standard of living*.

Local business maintains connections between producers and consumers. Sharing economy and local business enhance a sense of partnership, cooperation, and belonging. In fact, thriving local economies represent a deep-rooted democracy in which communities have opportunities to decide matters pertaining to their everyday life. *Local products and services* strengthen the vitality of the area. If money circulates five times or more in its place of origin, it generates a small economic boom (Max-Meef 2010, p. 204). This is a good news to sharing commodities such as tools, clothes, and vehicles. Sale of services may include art galleries and gyms, as well as maintenance, repair, and rental services. Use of services is often less materially and energy intensive than owning commodities. It also supports local labor intensity. Local business is also more transparent and accountable than global markets. Ecological and social responsibility is often stressed when the producer and consumer are near each other (Helne and Salonen 2016). Versatile and inclusive local economies are attractive as they foster trust and confidence that is at the heart of all economic activity (Diener et al. 2009).

Transformative Responses to Sustainability, Table 2 Comparing weak responses to strong responses

Weak responses to sustainability	Strong responses to sustainability
Standard of living	Quality of life
Focus on desires and wants	Focus on human needs
Global products and services	Local products and services
Linear economy	Circular economy
Market economy	True costs economy
Fossil energy	Clean energy
Consumer citizenship and individualism	Active citizenship and belonging

From the standpoint of nature, economic growth is a process of transferring natural resources to landfills. Excessive mining is needed because of *linear economy.* As a result of linear economy, it is estimated that Japanese urban areas contain 16% of the world's gold and 22% of silver (NIMS 2008). A shift from excessive mining to the circular economy is necessary simply because nonrenewable resources are not renewable.

Nature does not waste anything, but, instead, everything circulates. Material and energy flow forever. This idea is called *circular economy.* In a society, homes, cities, or soils are not ends but means to the next cycle of consumption. Wastes and emissions are evidence of incorrect product or service design (Salonen and Åhlberg 2012). In fact, there is no need for the term "waste." The only thing to be eliminated is toxins due to their accumulative and disruptive nature in the liver, kidneys, and central nervous systems of humans and animals. Heavy metals negatively affect growth, reproduction, and the activity of the different organism in the natural ecosystems (Pepper et al. 2011).

Market mechanisms fail to address the accumulation of individual everyday actions into collective social costs. Efficient markets are

transparent. There are no hidden costs. In a *true cost economy,* prices tell the truth. Externalities are included in the prices of commodities and services (Rees 2014, pp. 195–196). For example, each stage in the life cycle of coal – extraction, transport, processing, and combustion – generates a waste stream. Each stage includes hazards for health and the environment. These costs are typically considered externalities, and they are not included in prices. Accounting for the costs of damages doubles or triples the price of electricity from coal per kWh generated. This makes renewable energy economically competitive (Epstein et al. 2011). The situation is the same with other commodities we use in our everyday life. Switching to *clean energy* is one of the most effective ways to achieve a sustainable society because methods to produce energy are linked to ecological integrity, safeguarding biodiversity, democracy, nonviolence, and the peaceful coexistence of people. *Fossil energy*–driven climate change threatens social justice and human dignity (World Bank 2012), which are on the agenda of a socially sustainable society (Hämäläinen and Matikainen 2018, p. 28). Even if we live on a finite planet, raw materials and pollution are rarely taxed. Instead, the majority of government income from business is personnel related (Wintzen 2014, p. 299). In general, from the point of view of the citizen, society, and the planet, it is better to tax depletion and pollution than to tax labor and capital.

Active citizenship has many faces on different levels. In a neighborhood, an active citizen builds bonds between people from different backgrounds. For example, neighborhood gardens involve collaboration, knowledge sharing, and shortening the geographic distance from garden to dinner table. This improves happiness and saves resources simultaneously (Helliwell 2014). The current information society offers incredible possibilities to active citizenship. For example, the #metoo campaign is an example of active citizenship and rapid social awakening on a global level. This awakening refers to healthy and well-functioning society with active citizens that have the capacity to exercise moral judgment and the ability to feel compassion (Rees 2014). Even the emergence of a global civil society is possible through networking, at least on a certain level (Mitrani 2013). On the other hand, the challenge is this: "It is easier and perhaps more plausible to imagine a future of hyper-efficient, solar-powered, sustainable, and authoritarian societies than reformed and effective democracies" (Orr 2014, p. 220).

Holistic transformative responses to sustainability are necessities because on the finite planet resources are limited. However, mainstream thinking and politics often try to maximize the number of products and services by almost any means. If our goal is primarily economic growth, it is tempting to do things that do not directly address the creation of opportunities for a long, healthy, and meaningful life for people. The challenge is this, we accept negative things if the economy just grows. Should we then, as a whole society – private sector, public sector, and civil society together – guarantee long, healthy, and meaningful life in dignity at the lowest possible cost to every citizen without growing the economy bigger than necessary? In sustainable society, economy is for people, and policy-making is for the well-being of citizens.

With transformative responses to sustainable development, higher education builds a society in which citizens have good reason to wake up to a new day. Their living has a rich content and precious purpose. This requires, above all, combining different people's skills in communities, maximizing citizens' experience of inclusion in society, and increasing the human ability to repeatedly overcome old habits and routines in everyday life. In doing so, it is possible to maximize life satisfaction and the happiness of citizens.

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