



How to integrate Sustainability Teaching and Learning in Higher Education Institutions?
From Context to Action for transformation towards SDGs implementation

a literature review

TITLE

How to integrate Sustainability Teaching and Learning in Higher Education Institutions? *From Context to Action for transformation towards SDGs implementation* - a literature review -

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List of acronyms

BI: Behavioral Intentions

CRE: The Copernicus Programme of the Association of European Universities

EW: Ecological Worldview

EE: Environmental Education

EF: Ecological Footprint

EW: Ecological Worldview

ESD: Education for Sustainable Development

EUSTEPs: Enhancing Universities' Sustainability Teaching and Practices through
Ecological Footprint

GHESP: Global Higher Education for Sustainability Partnership

HEI: Higher Education Institutions

IAU: International Association of Universities

IUCN: International Union for Conservation of Nature

NGO: Non-Governmental Organization

PBC: Perceived Behavioral Control

PEB: Pro-Environmental Behavior

PN: Personal Norms

SDG: Sustainable Development Goal

SD: Sustainable Development

UN: United Nations

UNESCO: United Nations Educational, Scientific and Cultural Organization

UNU: United Nations University

1. Introduction

As Albert Einstein once said, “the significant problems we face cannot be solved at the same level of thinking we used when we created them” (Calaprice, 2000, p. 317). Our current way of thinking and existing is in need of a vital transformative shift of values and actions by all of society including leaders, professionals, as well as the population at large. That is why the belief that higher education can serve as a model of sustainability, by fully integrating all aspects in its activities (Cortese, 2003), is now more needed than ever.

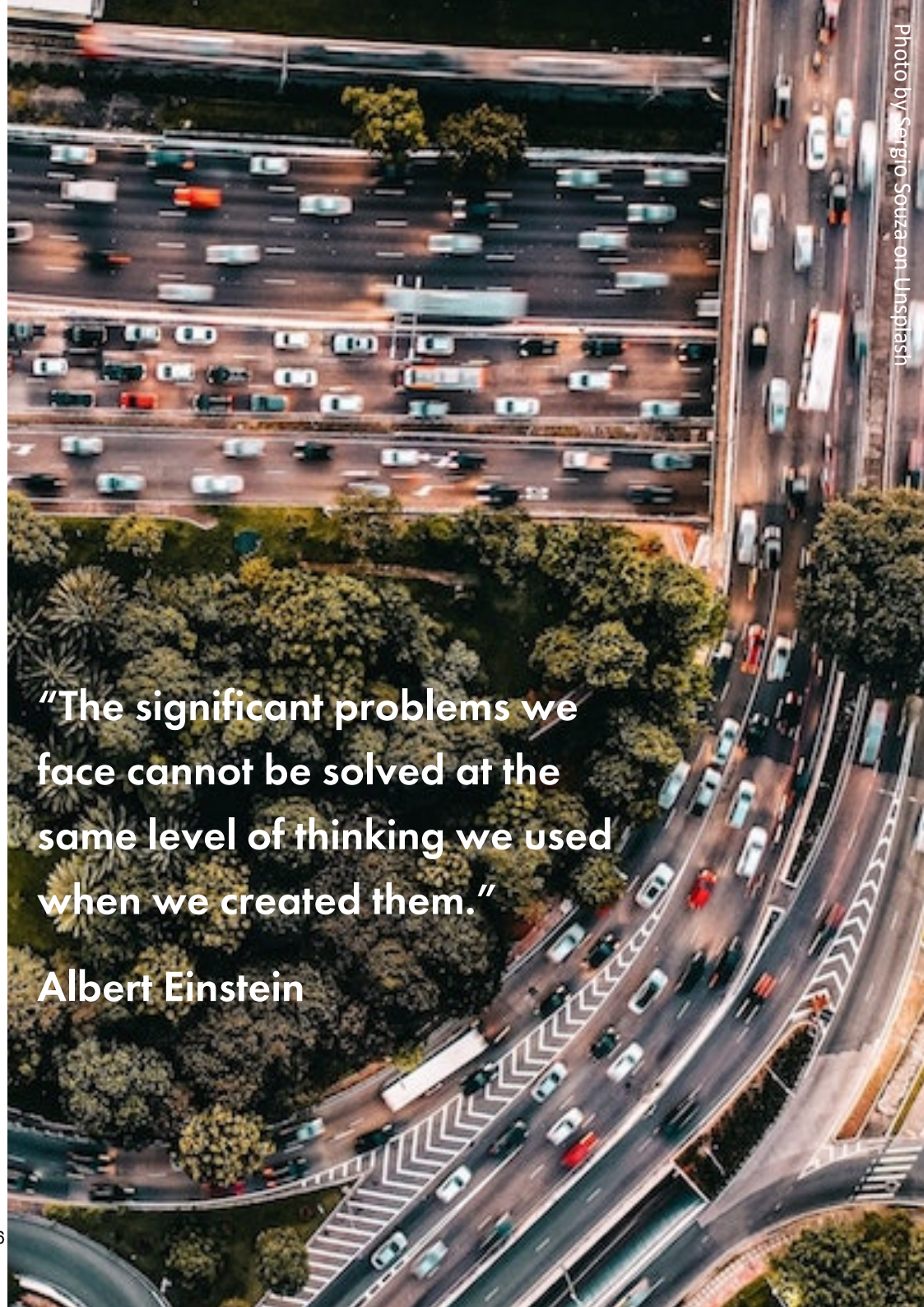
The recognition that we are living a global crisis of values, ideas, perspectives and knowledge, which makes it also a crisis of education (Orr, 1994), is the first step toward the so needed change in the Higher Education Institutions (HEIs) systems. HEIs – meaning the organizations that provide higher, postsecondary, and/or third-level education such as traditional universities, profession-oriented institutions or community colleges, liberal arts colleges, institutes of technology and other collegiate level institutions – are ethically and morally responsible to increase the awareness, knowledge, skills, and values needed to create a more sustainable way of living (Cortese, 2003). Since the 1972 United Nations (UN) Stockholm Conference, the education system has been recognized as key in fostering environmental protection and gained a central role in easing the transition to a sustainable world. Twenty years later, the UN Agenda 21 has called for reorienting education towards sustainable development, and UNESCO has launched the Decade of Education for Sustainable Development (2005-2014) and the Global Action Programme on Education for Sustainable Development (2015-2019). With the adoption of the UN Agenda 2030 in 2015, education has been linked with 16 of the 17 Sustainable Development Goals (SDGs) and is the focus of one specific Goal: SDG4 - Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. SDG Target 4.7 particularly states that “by 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through

education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture’s contribution to sustainable development” (UN, 2015).

Given the importance HEIs have in our society and considering the number of students, teaching staff as well as administrative and management staff they host every day, it becomes fundamental to ensure that sustainability is not only taught but also practiced within campuses. This was the fundamental reason for building a strategic partnership across four European universities and one international Non-Governmental Organization (NGO) to set up the ERASMUS+ EUSTEPs project - Enhancing Universities’ Sustainability Teaching and Practices through Ecological Footprint – in order to undertake both theoretical and practical activities to develop a new generation of sustainable citizens. With the inclusion of the Ecological Footprint (EF) concept and several educational tools and approaches, the project aims to educate students and the wider university community on the sustainability implications of personal behaviour, and to enhance new professional expertise in the society and in the future labour market. The role that Ecological Footprint can have in communicating the scale and significance of humanity's overuse of the planet's natural resources in simple and powerful terms, has long been acknowledged and this project thus intends to leverage on that and deliver on the following four key objectives: 1) to develop interactive teaching modules, materials and tools for the academic community to become Footprint ambassadors; 2) to build a Massive Open On-line Course made available through the project web-platform to scale-up project outcomes and enlarge the target audiences; 3) to involve all members of the university community in the co-development of an online, freely available University Footprint calculator about the environmental pressure of universities; and 4) to initiate a process of campuses greening, thus reducing their resource demand.

This study is one of the first steps of the project, and aims to provide a state-of-the-art review of existing sustainability teaching experiences in order to identify the necessary material(s) and tool(s) needed to reach-out to all the stakeholder groups within academia: i) undergraduate and master students, so that they can grasp the full complexity of sustainability and how it relates to their daily activities, as well as PhD students so that they can lead the University Footprint calculator development; ii) teaching staff, so that they can adopt the developed teaching and learning modules in their courses and disseminate them across other Departments and Faculties; iii) administrative staff, so that they can engage in developing the calculator and actively contribute to measuring and influencing the Footprint of their university and work space; iv) management bodies of the HEI, so that they can understand the impact of management practices in the reduction of the Footprint of the university. This review focuses on Education for Sustainable Development (ESD) knowledge and on critical comprehensive revisions of the literature that explores it.

Therefore, the next section defines the concept of holistic integration of sustainability into HEIs and explain the phases but also the barriers, drivers and challenges of such a holistic approach. It also summarizes the main international commitments towards sustainability learning and practicing in HEIs to briefly explain the evolution occurred in the last decades. Section 3 focuses on the emerging trend themes and patterns of research, teaching and curricula in the area of sustainability worldwide and on understanding the sustainability competencies needed and pedagogical approaches used within HEIs education and teaching for sustainability. Section 4 details relevant examples of Footprint teaching methods applied in HEIs and other educational institutions aiming to understand the type of projects and tools used, their outcomes and challenges. Conclusions on section 5 balance the gaps in current teaching and build on the analysed practices to discuss the way forward and how EUSTEPs can contribute to the developing of new learning tools and the fostering of collaboration between HEIs.



“The significant problems we face cannot be solved at the same level of thinking we used when we created them.”

Albert Einstein

2. The critical need for a holistic integration of sustainability into Higher Education Institutions (HEIs)

In recent decades, many HEIs have aligned themselves with the principles of sustainability (Adams et al., 2018). They have the vision, the knowledge and the power to lead the transition toward sustainability, and to induce the changes towards this new paradigm. Within Agenda 2030, education has been linked with almost every single SDG (Collins et al., 2018) and it is particularly highlighted in SDG4 on Quality Education, and the core SDG target 4.7, as well as it provides a global and inclusive framework for the implementation of sustainable development in HEIs (Arezes et al., 2019). Therefore, sustainability values are being pushed to be incorporated in all Higher Education Institutions' mission and practices (Arezes et al., 2019). Nevertheless, a holistic understanding of how to incorporate sustainability-related initiatives into HEIs in an integrated way is still a critical challenge of today. The next section briefly revises how environmental education shifted to sustainable development education in HEI. Section 2.2 approaches the different stages and challenges of the process of inclusion and integration of sustainability foundations, principles and practices within HEIs action. A critical overview of key international processes towards sustainability learning and practicing in HEI ends chapter 2 of this literature review.

2.1 Integrating Sustainability within Higher Education Institutions: from environmental to sustainability education

The integration of sustainable development (SD) has become a relevant topic in higher education as HEIs are increasingly attempting to take responsibility as agents in promoting its principles (Stough et al., 2018). They play an important role in transforming societies (Ramos et al., 2015) due to their double role including i) creating

knowledge and transferring this knowledge to the society, and ii) preparing students for their future role in society (Stough et al., 2018). As such, HEIs are faced with increasing requests to disclose how they integrate, and contribute to, sustainability. Despite the essential role of higher education in contributing to a sustainable society, there is a tension between different normative views of what is "sustainability/sustainable development" and "what universities should do" (Stough et al., 2018). So, in this section, a short overview of some considerations that make sustainability a contested concept is first provided and the way in which this concept applies to HEI are then briefly explored.

From the 1987 Brundtland Report (Brundtland, 1987), to the 2012 Rio Earth Summit (UN, 2012), sustainable development as a concept has made enormous progresses, becoming an established field of research (Wilson & Wu, 2017). In Our Common Future report, sustainable development was defined as an approach to development that meets current needs without compromising the ability of future generations to meet their own needs (Brundtland, 1987).

This approach has led to significant debate over the interrelationship (Wilson & Wu, 2017) that sustainability requires among environmental, social, and economic demands (Hou et al., 2014), complemented by core institutional objectives (Spangenberg, 2002). Pulselli et al. (2016) for instance, argue that sustainability is the opportunity to talk about humankind and to study the relations between humans and their context (physical, environmental, social, economic, political, urban, juridical, etc.). As already argued by Odum in 1977, sustainability implies a holistic approach in "the sense of seeking to understand large components as functional wholes" (Odum, 1977). Pulselli et al. (2016) argue that it is the opportunity to raise critical questions such as:

- 1) What should be sustainable? How to embrace a shared (holistic) and transdisciplinary picture of the reality in order to encompass the many dimensions of the context in which we live?

- 2) Why should we be sustainable? Is the purpose to create and maintain the conditions for durably living better and in harmony with nature and the other individuals?
- 3) How can we be sustainable? How to assess the critical conditions to reach sustainability? What type of (new) frameworks do we need to evaluate progress towards the desired change?

While definitions of sustainability in higher education vary, commonalities include the four dimensions: the environmental (defined as the sum of all biophysical processes and the elements involved in them), the social (intra-personal qualities of human beings), the economic (the formal and informal economic activities that provide services to individuals and groups), and the institutional dimension, particularly within the realms of campus life (including employees, students, and campus operations) (Lidstone et al., 2015; Spangenberg, 2002). However, the development and focus of sustainability issues in HEIs have experienced several shifts.

In recent years, there has been an evolution from environmental issues towards a broader sustainability approach, geared at empowerment and capacity building (Disterheft et al., 2015). Also, the literature focus, previously put on environmental sustainability, has shifted more recently to articles on pedagogy, competencies, community outreach and partnerships towards sustainability. However, the focus is still primarily on environmental sustainability, and more holistic approaches are necessary to achieve the proclaimed paradigm change towards all aspects of sustainable universities (Disterheft et al., 2015).

The roots of education for sustainable development (ESD) can be credited to the environmental education (EE) movement started in the early 1970s (Monroe, 2012; Stough et al., 2018). This historic root of ESD created a tendency for a predominant environmental-focused conceptualization (as can be seen in the emphasis some sustainability assessment tools give to environmental topics) (Lidstone et al., 2015; Stough et al., 2018). However, EE recognized that environmental issues were

integrated within other dimensions of sustainability, as can be seen by the first of the three EE goals: *“to foster clear awareness of, and concern about, economic, social, political, and ecological interdependence in urban and rural areas”* (Monroe, 2012). Currently, the ESD paradigm is addressing comprehensive transformative learning and provides equal attention to economic, social, environmental and institutional concerns.

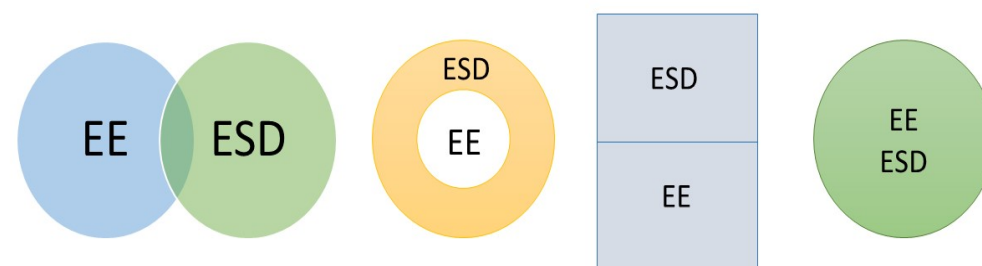


Figure 1. The relationship between EE and ESD in different approaches. Adapted from Eilam & Trop (2010)

Different approaches exist in literature to describe the EE-ESD relationship: ESD encompassing part of EE, EE as the foundation for ESD, EE and ESD as two different but complementary approaches or a complete overlap between the two (Eilam & Trop, 2010). Given the existence of such diverging views, it becomes evident that integrating sustainability into HEIs is a complex task (Lidstone et al., 2015). The discourse of ESD creates a broader and more complex agenda than environmental education, which becomes simultaneously a more ambiguous approach (Stevenson, 2007).

2.2. Evolution, barriers and challenges towards a holistic integration of sustainability into Higher Education Institutions

HEIs are key actors to promote sustainability through all dimensions of their activities: education (teaching and learning), research, outreach activities, campus operations, institutional governance, assessment and communication, and in the nexus of these areas (Kapitulčinová et al., 2018). Progress on this holistic integration of sustainability into university practices, the process we can term as “sustainability integration in higher

education”, has recently been gaining increasing attention worldwide (Alonso-Almeida et al., 2015; Lozano et al., 2015a; Kapitulčinová et al., 2018), with stronger interest in HEIs in Europe (Karatzoglou, 2013; Lozano et al., 2015a). Kapitulčinová et al. (2018) schematized the three different stages of the process of “sustainability integration in higher education”, namely (i) initiation/awakening, (ii) implementation/pioneering, and (iii) institutionalization/transformation, from a “business-as-usual university” to a “sustainable university” (Fig.2).

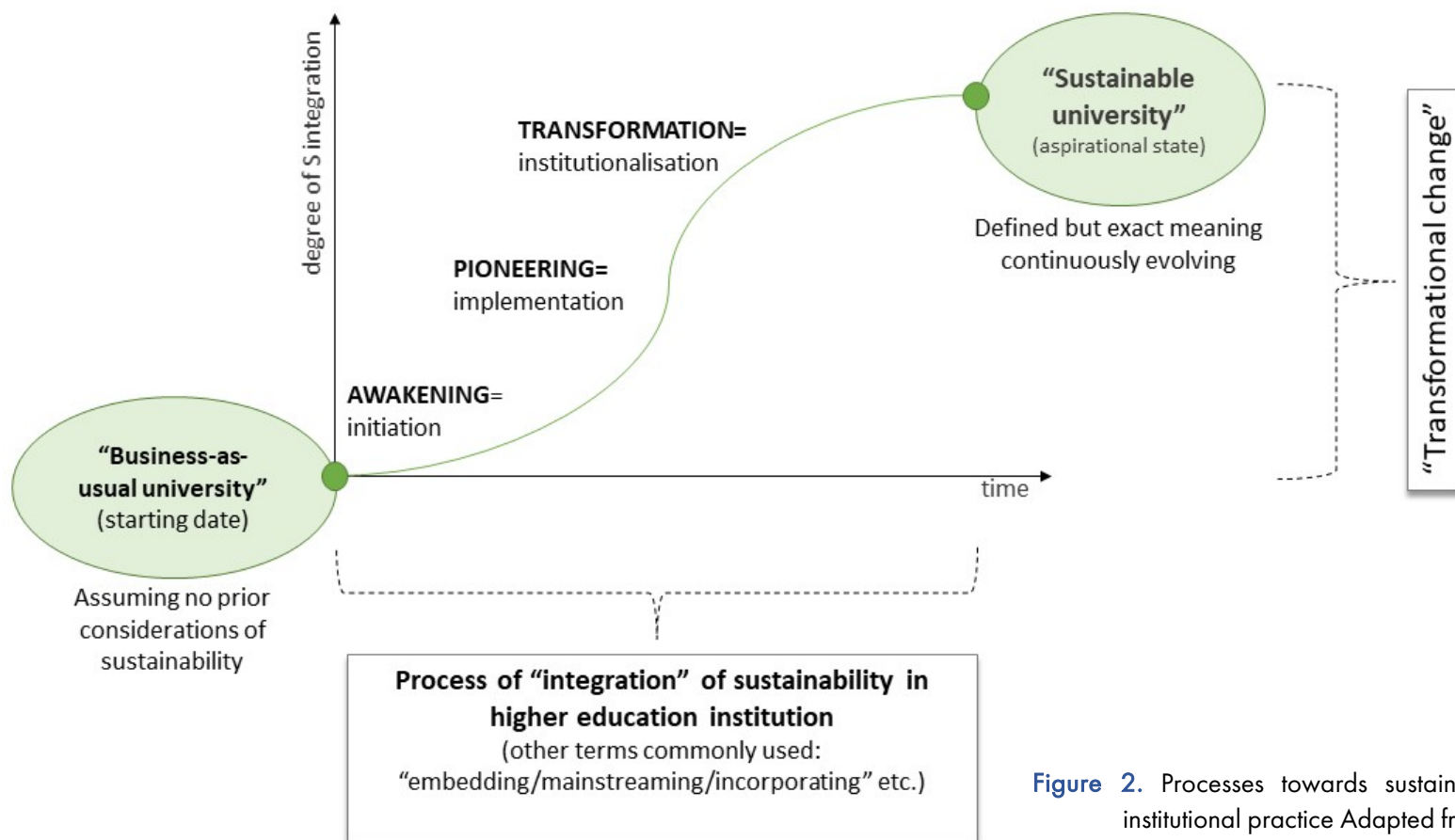


Figure 2. Processes towards sustainability integration into all dimensions of institutional practice Adapted from Kapitulčinová et al. (2018).

Kapitulčinová et al. (2018) argue that if HEIs focus on sustainability integration into all dimensions of institutional practice, they are more able to educate the academic community by providing a holistic experience and a more integrated ESD learning at the institution and beyond. So, the role that they have to play in the transformation towards a more sustainable society is attested to in both the scholarly and practitioner literature (Adams et al., 2018).

However, the adoption of whole-institution approaches and integrated frameworks by the academic community still appears to be in initial stages (Lozano et al., 2013a,b; Sammalisto et al., 2015 in Kapitulčinová et al., 2018); this is a situation, as we will see in the following sections, which international efforts should be focused on.

Some of the identified key reasons and barriers for this are related to factors such as human resistance to change, communication deficits, low empowerment and involvement, and rigid organizational culture (Verhulst & Lambrechts, 2015; Kapitulčinová et al., 2018). As explored by Trencher et al. (2014), the most frequent are human barriers rather than technical, mostly related to internal organizational dynamics such as time restraints, lack of unity and harmony, and the difficulties to overcome boundaries between disciplines when dealing with a transdisciplinary approach such as sustainability. If HEIs are to deliver on their promise of providing tomorrow's leaders, managers, scientists and teachers with the knowledge and cognitive skills to address the challenges of sustainability, then these shortcomings need to be addressed (Adams et al., 2018).

Some barriers have also been diagnosed already several years ago (Lozano, 2006) but they have been persisting throughout time. These are linked to the low relevance given to SD, the lack of resources or available financing for sustainability projects, the lack of staff, deficiencies in university educators' professional development, weak

strategies within HEIs or the lack of network cooperation among HEIs or the lack of governmental policies to encourage HEIs to implement ESD and sustainable practices¹ (Leal Filho et al., 2017, 2018, 2019; Lozano, 2006, 2015b; UNESCO, 2014). A summary of the main literature findings about barriers and challenges towards integration of sustainability into HEIs is illustrated in Table 1.

¹ For instance, a pioneering policy example is the recent initiative of the (former) Italian Ministry of Education, University and Research to include one hour per week on Sustainable Development and

Climate Change for all primary, secondary and high school students, which has been "celebrated" as the first action of this kind in the world, a "forefront in environmental education" (<https://www.nytimes.com/2019/11/05/world/europe/italy-schools-climate-change.html>)

Table 1. Summary of the barriers and challenges towards HEIs' sustainability integration

Category	Barriers/ Challenges	References
Human resources	Lack of unity and harmony	Trencher et al., 2014
	Resistance to change	Kapitulčinová et al., 2018
	Poor communication	Mendoza et al., 2019; Kapitulčinová et al., 2018; Trencher et al., 2014
	Poor empowerment and involvement	Kapitulčinová et al., 2018
	Limited specialization	Mendoza et al., 2019
	Lack of staff to coordinate sustainability efforts	Brandli et al., 2015
Cultural barriers	Organizational culture	Kapitulčinová et al., 2018
	Cultural differences (e.g., race, religion, gender) produced by path-dependency, lack of trust, and significant disagreement towards the values being encountered	Lozano, 2006
	Resistance to cultural change	Brandli et al., 2015
Social and Institutional barriers	Locked-in lifestyles	Trencher et al., 2014
	Poor socio-economic conditions	Trencher et al., 2014
	Lack of capacity and pressure from society	Trencher et al., 2014; Ferrer-Balas et al., 2008
External funding/ Budget/ Finance	Lack of/few financial resources or available external funding (length and amount) for sustainability projects	Trencher et al., 2014; Brandli et al., 2014; Mendoza et al., 2019
	Lack of allocated funding to departments - infrastructure/structures	Moore, 2005
	Lack of allocation of responsibilities and institutional budget	Mendoza et al., 2019
Leadership and management	Poor leadership or management	Trencher et al., 2014
	Lack of teams of senior managers/leaders (combining operational and strategic staff)	Mendoza et al., 2019
	Lack of strategic leadership and institutional support	Mendoza et al., 2019
	Weak commitment and resistance to change	Mendoza et al., 2019; Özuyar & Moreira, 2017
	Few Incentive structures, based on traditional academic incentive systems and norms	Ferrer-Balas et al., 2008; Mendoza et al., 2019; Trencher et al., 2014
Governance and policy-making structure	Unclear decision-making structures	Moore, 2005
	Conservative organizational structures and governance, based on the hierarchy of power—administration: faculty, staff and students	Mendoza et al., 2019; Moore, 2005; Ferrer-Balas et al., 2008
	Lack of national government policies to encourage the implementation of education for sustainability in HEIs	Brandli et al., 2014
	Lack of rules, guidelines, schedules and control systems	Kanyimba et al., 2014; Ávila et al., 2017

Table 1. Summary of the barriers and challenges towards HEIs' sustainability integration

Category	Barriers/ Challenges	References
Misdirected criteria for evaluation	Faculty promotion and hiring based on publication records	Moore, 2005
	Student surveys on exit opportunities only focus on jobs and salaries as criteria for student evaluation	Moore, 2005
	Lack of clear evaluative structures/indicators for university policy and plans	Moore, 2005
	Poor critical processes to assess the impact of ESD initiatives	Decamps et al., 2017
	Lack of data collection systems and performance indicators on SD	Mendoza et al., 2019
Collaborative barriers	Few faculty members engaged in ESD (they don't always perceive ESD as a pedagogical issue)	Decamps et al., 2017
	Few networks among HEIs to foster cooperation	Brandli et al., 2014
	Few Research & Development (R&D) projects between HEIs and companies	Brandli et al., 2014
	Few external stakeholders' engagement and collaboration	Mendoza et al., 2019
Teaching and Learning settings in communities and institutions	Lack of understanding, ability and skill of staff to teach ESD subjects	Kanyimba et al., 2014; Mendoza et al., 2019
	Low awareness and knowledge on environmental issues, circular economy, or sustainability in general	Trencher et al., 2014; Mendoza et al., 2019; Brandli et al., 2014
	Lack of importance of sustainability topics for students; sustainability is not necessarily considered legitimate and important by most	Decamps et al., 2017; Brandli et al., 2014
Internal barriers	Competitive environment between and within: students (for grades), faculty (publication, grants), Departments (students, funding), Universities (prestige, power, etc.)	Moore, 2005
	Technological barriers	Trencher et al., 2014

As for the drivers that lead the needed organizational changes towards sustainable practices, the role of critical international agreements and global developments to push for such transformations at a higher scale of influence is undeniable. These key international agreements will be detailed in the next section. Lozano et al. (2015a) assessed whether commitment to SD through the signing of a declaration, charter or other international initiatives for sustainable development resulted in better implementing sustainable development within HEIs and their conclusions point to positive associations. The same authors concluded that not only there is a high correlation between commitment and implementation in HEIs, when signing some sort of declaration, but also SD commitment leads to this signing and further application of SD. Apart from that, when compared to primary and secondary education, HEIs are also organizational structures with relative autonomy as well as regarding their teaching and research activities (Kapitulčinová et al., 2018), and therefore more able to benefit from individual agency, relationships, institutional cultures and power on campus (Hoover & Harder, 2015). The pressures from peer institutions or the sources of funding available contribute furthermore to enhance these transformations (Ferrer-Balas et al., 2008). Within the internal structures of HEIs, critical drivers have been the leadership and the role of “change agents”, meaning individuals (including faculty, researchers, or students) that are formally or informally involved in active and conscious efforts to motivate those changes (Kapitulčinová et al., 2018). Lozano et al. (2013b, p. 11) argue that *“university leaders and staff must be empowered to catalyse and implement new paradigms and ensure that SD becomes the ‘Golden Thread’ throughout the entire university system”*. These internal factors indicate that activities at universities are often influenced by a bottom-up level, and where the role of individuals is crucial, yet often not recognized as an important success factor (Verhulst & Lambrechts, 2015). The main internal and external drivers towards integration of sustainability into HEIs are summarized in Table 2 (see next page).

To take advantage of the drivers and to overcome the mentioned barriers, some recommendations have been proposed by different authors (e.g., Lozano, 2006; Adams et al., 2018) but always underlying that there are no single “recipes” of what

“ingredients” to use to ensure success (Kapitulčinová et al., 2018). Some of the approaches can be related to more technological solutions to sustainability challenges, while others to whole-institution approaches and integrated frameworks, as seen before (Adams et al., 2018). According to the UNESCO, *“deeper innovation in staff development and across institutions is necessary to transform curricula and pedagogy”* (UNESCO, 2014).

Table 2: Summary of main drivers towards integration of sustainability in HEIs

Categories	Drivers	References
Internal drivers	Partnership synergy	Trencher et al., 2014
	Strong and visionary leadership	Ferrer-Balas et al., 2008; Trencher et al., 2014
	Coordination structures	Ferrer-Balas et al., 2008; Trencher et al., 2014
	University policy	Trencher et al., 2014
	Sustainability champions	Ferrer-Balas et al., 2008; Lozano, 2006
	Connectors (existing networks of people that reach across the HEI to include a critical mass of actors)	Ferrer-Balas et al., 2008
	Size (small HEIs have more rapid transformation processes)	Ferrer-Balas et al., 2008
	Commitment	Lozano et al., 2015
	Personal contributions (that can be provided from a personal expertise)	Lazzarini and Pérez-Foguet, 2018
	Diverse perceptions of academics about the nature of SD	Lazzarini and Pérez-Foguet, 2018
External drivers	External funding available	Ferrer-Balas et al., 2008; Lozano et al., 2015; Trencher et al., 2014
	National government support policy	Trencher et al., 2014
	International and national policies	Adams et al., 2018
	Societal 'need' and demand	Trencher et al., 2014
	Positive societal forces (i.e., progressive or environmentally aware society, strong culture of collaboration and innovation, etc.)	Trencher et al., 2014
	Pressure from peer institutions	Ferrer-Balas et al., 2008
	Ranking mechanism tends to use competition between HEIs	Wals, 2014



2.3 Overview of key international processes towards sustainability learning and practicing in HEIs

Efforts in sustainability learning and practicing in HEIs are the result of international processes and global developments. But those global initiatives are also shaped by universities. Along these multilateral agreements, international as well as national influence (e.g., through sustainability-specific projects or funding programs) are also key determinants of HEIs actions towards sustainability (Kapitulčinová et al., 2018).

Since 1945, UNESCO has played a central role in promoting sustainable development and intercultural dialogue through education, sciences, culture, communication and information. In 1972, the United Nations put the first stone of a new environmental paradigm by organizing the first major conference on international environmental issues that took place in Stockholm – the Conference on the Human Environment – which represented a first taking stock of the global human impact on the environment (Handl, 2012). This approach was a truly turning point in the development of international environmental politics and resulted in the publication of the first declaration of the UN towards *“the need for a common outlook and for common principles to inspire and guide the peoples of the world in the preservation and enhancement of the human environment”* (UN, 1972). Among the 26 principles subscribed in Stockholm, the 19th Principle regarded Education in environmental matters, in order to hold individuals, enterprises and communities responsible in protecting and improving the environment

(UN, 1972). Furthermore, the 95th recommendation established an international programme in educational, informational, social and cultural aspects of environmental issues with an interdisciplinary approach within all levels of education with the aim to educate all towards the simple steps everyone should take to manage and control its environment (UN, 1972).

In 1987, the Brundtland Commission's report reaffirmed the importance of educating young people to build *“a development which meets the needs of current generations without compromising the ability of future generations to meet their own needs”* (Brundtland, 1987). Henceforth this became the official definition of sustainable development. Twenty years after Stockholm, Rio de Janeiro hosted the 1992 UN Conference on Environment and Development (UNCED), where the second global environmental Declaration was issued (Handl, 2012). Agenda 21 recognized universities and research centres as critical stakeholders and encouraged Member States to support their (re)orientation towards sustainability. Ten years later, the Johannesburg Plan of Implementation (2002) highlighted the capacity building in ESD and stakeholder collaboration among HEIs as key approaches towards sustainability (UE4SD, 2015). Table 3 summarizes a timeline of the most recognized events or declarations that fostered higher education for sustainable development since then, along with their main principles for HEI.

Table 3. Timeline of the initiatives taken in society, education, and higher education to foster sustainable development, from 1972 to 2019 (Source: Adapted and expanded from Lozano et al., 2013b, and Disterheft et al., 2013)

Year	Event/Declaration	Partners Involved	SCOPE	Level or focus	Relevant points for Higher Education Institutions	Hyperlink
1972	Stockholm Declaration on the Human Environment	UN, UNESCO	Society	Global	Principle 19: Education in environmental matters as essential to development	https://legal.un.org/avl/ha/dunche/dunche.html
1975	The Belgrade Charter, Belgrade Conference on Environmental Education, former Yugoslavia	UNESCO, UNEP	Education	Global	"Environmental education, properly understood, should constitute a comprehensive lifelong education" and improve future of life and the planet (https://www.gdrc.org/uem/ee/belgrade.html)	https://www.eusteps.eu/wp-content/uploads/2020/12/Belgrade-Charter.pdf
1977	Tbilisi Declaration, Intergovernmental Conference on Environmental Education, Georgia	UNESCO, UNEP Governments (66 UNESCO Member States and observers and 2 non-Member States)	Education	Global	The first Intergovernmental Conference on Environmental Education (EE); EE should be integrated into the whole system of formal education at all levels to provide knowledge, understanding, values and skills needed by the general public and occupational groups, for their participation in devising solutions to environmental questions; expose the importance of obtaining an inter or multidisciplinary perspective in EE to <i>"understand the complex nature of the natural and the built environments resulting from interaction of their biological, physical, social, economic and cultural aspects"</i> .	https://www.gdrc.org/uem/ee/EE-Tbilisi_1977.pdf
1987	"Our Common Future", The Brundtland Report	WCED, UNESCO	Society	Global	The main targets were multilateralism and interdependence of nations in the search for sustainable development by broadening Education	https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf
1988	The Magna Charta of European Universities	European Universities	Higher education	Regional (Europe)	Universities must provide future generations with education and training towards sustainability.	http://www.magna-charta.org/magna-charta-universitatum
1990	Talloires Declaration, Presidents Conference, France	University Leaders for a Sustainable Future	Higher education	Global	First official statement made by university presidents, chancellors, and rectors to environmental sustainability in higher education. Signed by over 500 college and university presidents and chancellors worldwide.	http://ulsf.org/talloires-declaration/
1991	Halifax Declaration, Conference on University Action for Sustainable Development, Canada	Consortium of Canadian Institutions; IAU; UNU	Higher education	Global	Invites HEIs to implement 6 measurements towards sustainability in campus and teaching, assuming that they are effective contributors to behavioural and policy changes necessary for a sustainable future.	https://www.iau-hesd.net/sites/default/files/documents/rfl_727_halifax_2001.pdf

Table 3. Timeline of the initiatives taken in society, education, and higher education to foster sustainable development, from 1972 to 2019 (Source: Adapted and expanded from Lozano et al., 2013, and Disterheft et al., 2013)

Year	Event/Declaration	Partners Involved	SCOPE	Level or focus	Relevant points for Higher Education Institutions	Hyperlink ¹
1992	United Nations Conference on Environment and Development, Rio de Janeiro, Brazil	UN	Society	Global	Agenda 21: Chapter 36 - Promoting Education, Public Awareness and Training, and Chapter 35 - Science for Sustainable Development	https://www.un.org/esa/dsd/_agenda21/Agenda%2021.pdf
1992	Association of University Leaders for a Sustainable Future founded (ULSF), USA	College and university presidents and chancellors worldwide	Higher education	Global	ULSF supports Talloires signatories and promotes sustainability as a critical focus of teaching, research, operations and outreach in higher education through publications, research, and assessment.	https://ulsf.org/
1993	Kyoto Declaration, International Association of Universities (IAU) Ninth Round Table, Japan	IAU	Higher education	Global	Increased interest in sustainable campus, forcing universities to promote sustainability by reviewing their operations to implement best practices for sustainable development.	https://iau-aiu.net/IMG/pdf/sustainable_development_policy_statement.pdf
1993	Swansea Declaration, Association of Commonwealth Universities' Fifteenth Quinquennial Conference, Wales	The Association of Commonwealth Universities	Higher education	Global	Over 400 universities in 47 countries acknowledged that the "educational, research and public service roles of universities enable and impel them to be competent, effective contributors to the major attitudinal and policy changes necessary for a sustainable future."	https://www.iau-hesd.net/sites/default/files/documents/the_swansea_declaration.pdf
1993	COPERNICUS University Charter, Conference of European Rectors, Geneva	Association of European Universities	Higher education	Regional (Europe)	Commitment to SD by HEIs top managers through Institutional commitment, implementation of programs in EE; promotion of interdisciplinarity, and improvement of information towards employees, dissemination of knowledge.	https://www.iau-hesd.net/sites/default/files/documents/copernicus.pdf
1997	Thessaloniki Declaration, International Conference on Environment and Society: Education	NGOs, civil society, UNESCO and the Government of Greece	Education	Global	The need to reorient education for sustainability in the 21st century, reaffirming that "appropriate education and public awareness should be recognized as one of the pillars of sustainability together with legislation, economy and technology."	https://www.iau-hesd.net/sites/default/files/documents/thessaloniki.pdf
1998	World Declaration on Higher Education for the twenty-first century: Vision and Action, Paris	UNESCO, world leaders	Higher education	Global	Reinforce that education is a fundamental pillar for human rights, democracy, SD and peace, and shall be accessible to all; It defines missions for several societal, educational and other vectors; Sets forth a vision and guiding principles for the 21st century challenges, namely "the strong involvement of all society including government, higher education, and all stakeholders"; "Higher education must place students at the centre within a lifelong learning perspective. Students must be considered as equal and fundamental stakeholders."	https://unesdoc.unesco.org/ark:/48223/pf0000141952

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2000	Millennium Development Goals	UNESCO	Society	Global	Launch of the UN Millennium Goals. Goal 2: Achieve universal primary education	https://www.un.org/millenniumgoals/
2000	The Earth Charter	UNESCO, IUCN and thousands of other organizations	Society	Global	"9 b - Empower every human being with the education and resources to secure a sustainable livelihood and provide social security and safety nets for those who are unable to support themselves." [...] "14. Integrate into formal education and life-long learning the knowledge, values, and skills needed for a sustainable way of life. a. Provide all, especially children and youth, with educational opportunities that empower them to contribute actively to SD." [...]	https://earthcharter.org/wp-content/uploads/2020/03/earthcharter_english.pdf?x79755
2000	Global Higher Education for Sustainability Partnership (GHESP)	COPERNICUS, CRE, IAU, ULSF, UNESCO	Higher education	Global	MEMORANDUM OF UNDERSTANDING among HEIs with a significant commitment to make sustainability a major focus of higher education	http://portal.unesco.org/education/en/ev.php-URL_ID%34701&URL_DO%4DO_TOPIC&URL_SECTION%4201.html
2001	Lüneburg Declaration on Higher Education for Sustainable Development, Germany	Global Higher Education for Sustainability Partnership	Higher education	Global	Generate new knowledge to train leaders and teachers of the future, disseminate SD knowledge and promote continuous review and update of teaching curricula.	https://www.iau-hesd.net/sites/default/files/documents/luneburgdeclaration_0.pdf
2002	World Summit on Sustainable Development, Johannesburg, South Africa	NGOs, civil society, UNESCO and the Government of Greece	Society	Global	Main outcome: Decade of Education for Sustainable Development	https://iefworld.org/wssd.htm
2002	Ubuntu Declaration, World Summit on Sustainable Development, Johannesburg, South Africa	United Nations University, UNESCO, International Association of Univ., Third World Academy of Sciences, African Academy of Science, Science Council of Asia, International Council for Science, World Federation of Engineering Organizations, COPERNICUS CAMPUS, Global Higher Education for Sustainability Partnership, Univ. Leaders for a Sustainable Future	Education	Global	"Called for the creation of a global learning environment for education in sustainable development; to produce an action-oriented tool kit for universities designed to move from commitment to action; to indicate strategies for taking sustainable development; to suggest strategies for reform, particularly in such areas as teaching, research, operations and outreach; and to make an inventory of best practice and case studies."; curriculum development; North-South networking; strategic educational planning and policy-making; and capacity building in scientific research and learning.	https://www.unedforum.org/fileadmin/files/AMR_2008/UbuntuDeclaration.pdf

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Year	Event/Declaration	Partners Involved	SCOPE	Level or focus	Relevant points for Higher Education Institutions	Hyperlink ¹
2004	Declaration of Barcelona, Spain	Mayors and representatives of cities and regions from 18 European countries	Higher education	Regional (Europe)	Cited holistic thinking as a major goal of education, and stated that future professionals "should be able to use their expertise not only in a scientific or technological context, but equally for broader social, political and environmental needs."	https://www.iau-hesd.net/sites/default/files/documents/declaration_of_barcelona_english.pdf
2005	The UN Decade Education for Sustainable Development (DESD) 2005-2014	UNESCO	Education	Global	The main goal was to "integrate the principles, values and practices of SD into all aspects of education and learning" by catalysing new partnerships with the private sector, youth, and media groups; encouraging to monitor, evaluate and develop a research agenda and serve as a forum for relevant research on ESD among others.	https://en.unesco.org/themes/education-sustainable-development/what-is-esd/un-decade-of-esd
2005	Graz Declaration on Committing Universities to Sustainable Development, Austria	UNESCO, COPERNICUS CAMPUS, Karl-Franzens University Graz, Technical University Graz, Oikos International	Higher education	Global	"Called on universities to give status to SD in their strategies and activities. It also called for universities to use SD as a framework for the enhancement of the social dimension of European postsecondary education."	https://www.iau-hesd.net/sites/default/files/documents/2005_-_graz_declaration_on_committing_universities_to_sustainable_development_fr.pdf
2005	Bergen Conference	European education ministers, European Commission and other consultative members	Higher education	Regional (Europe)	Draw up national action plans to improve the quality of the process associated with the recognition of foreign qualifications (Bergen Communiqué, 2005:3); promote the implementation in European HEI's system of worldwide based on the principle of SD.	http://www.ehea.info/media.ehea.info/file/2003_Berlin/28/4/2003_Berlin_Communique_English_577284.pdf
2006	Declaration on the Responsibility of Higher Education for a Democratic Culture – Citizenship, Human Rights and Sustainability COPERNICUS Guidelines for SD in European Higher Education	COPERNICUS-CAMPUS Sustainability Center, COPERNICUS-CAMPUS University Alliance for Sustainability	Higher education	Regional (Europe)	Address the challenges HEIs face through striving for sustainability; give some orientation to help HEIs, in connection with the Bologna Process; establish that HEIs Area by 2010 should be based on the principles of sustainable development in a Europe of knowledge.	http://www.ehea.info/media.ehea.info/file/COPERNICUS_Olderburg_2006/92/6/COPERNICUSGuidelines_587926.pdf

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Year	Event/Declaration	Partners Involved	SCOPE	Level or focus	Relevant points for Higher Education Institutions	Hyperlink ¹
2008	G8 University Summit Sapporo Sustainability Declaration, Hokkaido	Presidents, Rectors, Chancellors, Vice-Chancellors and representatives of 27 of the leading educational and research institutions in the G8 member nations United Nations University and 7 universities from 6 major non-G8	Higher education	Regional	Reinforce the need to restructure scientific knowledge and the role of HEIs for sustainability, referring that HEIs are crucial for providing timely solutions to the problems and to closely coordinate with policymakers if the solutions are to be promptly and appropriately implemented particularly regarding Sustainability.	https://www.global.hokudai.ac.jp/about/contribution-to-a-sustainable-society/ssd/
2009	Tokyo Declaration of HOPE	UNESCO	Education	Global	Implementing and assessing student affairs programs and services.	https://unesdoc.unesco.org/ark:/48223/pf0000128118
2009	Abuja Declaration on Sustainable Development in Africa: The role of higher education in SD, Nigeria	Africa's HEIs, National Governments and Regional Organizations	Higher education	Regional	Revision of the educational system to effectively achieve Higher Education for Sustainable Development in Africa (HESDA).	http://gc.aau.org/report/declaration_12th_gc_aau9.pdf
2009	Turin Declaration on Education and Research for Sustainable and Responsible Development, Italy	G8 University Network	Higher education	Global	Universities should work closely with policymakers; their leadership role is becoming increasingly critical; educating; disseminating information; training leaders; interdisciplinary perspective.	https://www.iau-hesd.net/sites/default/files/documents/g8torino_declaration.pdf
2009	World Conference on Higher Education	UNESCO	Higher education	Global	HEIs were challenged to "think locally, but act globally" through partnerships, and good governance and social responsibility.	https://unesdoc.unesco.org/ark:/48223/pf0000189242?posInSet=3&queryId=N-EXPLORE-a5e03af4-811e-4699-8f8c-fe4653ebccf4
2010	The ISCN-GULF Sustainable Campus Charter, Davos, Switzerland	International Sustainable Campus Network and GULF Schools, Global University Leaders, World Economic Forum	Higher education	Global	"It provides universities and corporations a common framework to formalize their commitments and goals on campus sustainability, and a platform to publicly share achievements within a group of peer and leading organizations around the globe".	http://educacionysustentabilidad.tecsuma.cl/wp-content/uploads/2011/11/4-ISCN-GULF_Charter_Guidelines_20101027.pdf
2010	G8 University Summit: Statement of Action, Vancouver	G8/G20 Universities	Higher education	Global	For a Sustainable Energy, Health and Higher Education	https://president3.sites.olt.ubc.ca/files/2010/05/g8_signe_ddoc1.pdf
2011	Copernicus Charta 2.0	COPERNICUS Alliance (European Network on Higher Education for SD)	Higher education	Regional	Commitment to scale up European HEIs efforts towards a successful transition to a sustainable society, which is free, just, equal, solidary and tolerant, based on the experience gained.	https://www.copernicus-alliance.org/images/Downloads/COPERNICUSCharta_2.0.pdf

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Year	Event/Declaration	Partners Involved	SCOPE	Level or focus	Relevant points for Higher Education Institutions	Hyperlink ¹
2012	UN Higher Education Sustainability Initiative, Rio + 20	UN Academic Impact, UNESCO, UNEP, UN Global Compact, PRME, UNU	Higher education	Global	Revising teaching content to respond to global and local challenges; promoting teaching methods that enable students to acquire skills (interdisciplinary thinking, integrated planning, understanding complexity, cooperating with others in decision-making processes); participating in local, national and global processes towards SD.	https://www.unglobalcompact.org/news/248-06-20-2012
2012	People's Sustainability Treaty on Higher education, Rio +20	25 HEIs' representatives	Higher education	Global	Rethinking higher education and its role in a transition towards a more sustainable society by defining 8 principles to achieve it.	https://redcampussustainable.cl/wp-content/uploads/2018/03/4-People_s-Sustainability-Treaty-on-Higher-Education.pdf
2014	Aichi-Nagoya Declaration on ESD; Post-2015 DESD agenda	UNESCO	Education	Global	Transforming societies in key aspects of citizenship.	http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/ERI/pdf/Aichi-Nagoya_Declaration_EN.pdf
2015	Transforming our World: The 2030 agenda for sustainable development	UNESCO	Education	Global	Definition of the goals towards SDG4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.	https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E
2017	G8 University Summit Sapporo Sustainability Declaration report, Japan	27 educational and research institutions in G8; United Nations University; 7 univ. from 6 major non-G8 nations	Higher education	Global	Recognizing the expanding role of scientists and universities, and their responsibility to contribute towards the attainment of sustainability, and the specific actions they must undertake to fulfill that responsibility.	https://eprints.lib.hokudai.ac.jp/dspace/bitstream/2115/65159/5/34_The%20G8%20University%20Summit_The%20Sapporo%20Sustainability%20Declaration_all.pdf
2017	Higher Education Institutions Conference	UN Department of Economic and Social Affairs, UNESCO, United Nations Environment, UN Global	Higher education	Global	Higher Education Institutions – Key Driver of the Sustainable Development Goals	https://sustainabledevelopment.un.org/content/documents/17043HESI_Summary_2017.pdf
2019	Education 2030: Incheon Declaration and Framework for Action for the implementation of Sustainable Development Goal 4	UNESCO, UNICEF, World Bank, United Nations Population Fund, United Nations Development Program, United Nations Women, United Nations Refugees Agency	Education	Global	Definition of the strategy towards an effective implementation of the Sustainable Development Goals	https://unesdoc.unesco.org/ark:/48223/pf0000245656

With the declaration on the Decade of Education for Sustainable Development starting in 2005, the UN aimed to "*integrate the principles, values and practices of sustainable development into all aspects of education and learning*" by catalysing new partnerships within the private sector, youth, and with media groups and by encouraging the monitoring, evaluation and development of a research agenda on ESD, among others (see Table 1, page 11 and subsequent).

The UNESCO (2014) report that assessed the progress made by this decade provided evidence of the building of solid ESD foundations across all countries and regions: ESD worked as an enabler for sustainable development, galvanized pedagogical innovation and involved key stakeholders including those beyond the education sector. Despite the clear progress, ESD has not reached its full potential yet, and remains to be implemented systemically, with more attention to be paid to related research and innovation (UE4SD, 2015).

The most recent impetus was given by Agenda 2030, with education playing a critical role for 16 of the 17 SDG. The 2030 Agenda highlights education as a stand-alone goal (SDG 4) and also includes targets on education under several other SDGs, notably those on health; growth and employment; sustainable consumption and production; and climate change (UN, 2015). What is new about SDG4-Education 2030 is its focus on increased and expanded access, inclusion and equity, quality and learning outcomes at all levels, within a lifelong learning approach (UE4SD, 2015). The development of the UNESCO Education 2030 Framework for Action that followed the establishment of SDG4 is one of the most recent efforts to set a number of strategic approaches: from strengthening policies, plans, legislation and national systems to emphasizing equity, inclusion and gender equality (UNESCO, 2016).

According to Lozano et al. (2013a) the most accepted SD initiatives in higher education until 2013 were the Talloires Declaration, the Halifax Declaration, the Swansea Declaration, the Kyoto Declaration, the GHESP, the Copernicus Charter, the Lüneburg

Declaration, the Declaration of Barcelona, the Graz Declaration, the Turin Declaration, and the Abuja Declaration, which relate to the university system. These declarations were designed to encourage and support sustainable development in HEIs (Lozano et al., 2013a). Therefore, a large number of universities across the world have signed these declarations, showing how important the latter have become. Yet, the number of HEIs that signed these declarations "*is small compared to the total number of universities in the world*", says Lozano et al. (2013b). Roorda (2002) stresses that these documents contain important guidelines for education, but nevertheless do not offer concrete operational prescriptions on what to do.

3. Overview of teaching and curricula literature

3.1. Emerging trend themes and patterns of research, teaching and curricula in the area of sustainability worldwide

Regarding teaching and the development of sustainable development (SD) curricula in HEIs, considerable progress has been made in the last decade, and European HEIs have been leaders in this trend (Lozano et al. 2019). Barth and Rieckmann (2012) explained different patterns of ESD, from introductory processes to transformative curriculum change. According to Lozano et al. (2015a), a great number of scientific papers has been published between 2000 and 2013 with a focus on education, including curricula, pedagogies, competences, and educating the educators.

Lozano et al. (2015b) summarize five main approaches to incorporate SD into higher education curricula:

- I. the coverage of some environmental issues and material in an existing course or courses;
- II. the development of a specific SD course;
- III. the intertwining of SD as a concept in regular disciplinary courses, tailored to the nature of each specific course;
- IV. the consideration of SD as a possibility for specialization within the framework of each faculty;
- V. the development of an undergraduate or post-graduate SD program.

However, cases of whole curriculum reform towards sustainability are relatively limited and often pedagogies are not entirely appropriated to SD principles (Leal Filho et al., 2018). The limited progress in the integration of SD in university curricula is not

compatible with the urgency required to tackle it (Ramos et al., 2015; Leal Filho et al., 2018).

The study of Lozano et al. (2015a) identified that the most implemented actions in higher education are the ones that have a more limited impact, such as the possibility to take classes in another faculty; the integration of SD courses in some programmes, schools and faculties; and the presence of an optional SD course. Others less frequent, but more critical, have also been implemented (e.g., inviting SD guest lecturers promoting systems thinking in the teaching activities; providing continuous education to external stakeholders on SD; supporting SD education to educators; and having a SD course for all students) but further action is needed.

Some tools have been developed particularly to assess the results of sustainability research, teaching and curricula in HEI throughout the past decades. This is particularly relevant and a thoughtful revision of such tools (e.g., the Sustainability Tool for Assessing UNiversities Curricula Holistically STAUNCH®; the Sulitest -Sustainability Literacy Test or use of the Ecological Footprint) can be seen at Caeiro et al. (2020).

Leal Filho et al. (2018) argue that transformation in ESD requires the commitment of faculty and the engagement of students, as well as the development of collaborative approaches among academics. Also, the discussion on how to redesign their own disciplines and their own values is crucial for developing the transformative potential of students as agents of a sustainable future.

Nevertheless, criticisms have been directed to HEI, emphasizing that most of the approaches in ESD do not address the root causes of current societal crises (Kaufmann et al., 2019). Amador et al. (2015) argue that ESD is frequently a way of propagating experts' ideas and dominant economic paradigms about sustainable development, rather than an opportunity to develop critical thoughts of the existing society and to address participatory and metacognitive engagements over what is really needed to question from a plurality of alternatives.

One of those criticisms points to the need to include non-traditional aspects of sustainability in the discourse (Ramos et al., 2015). Others stress the fact that most ESD

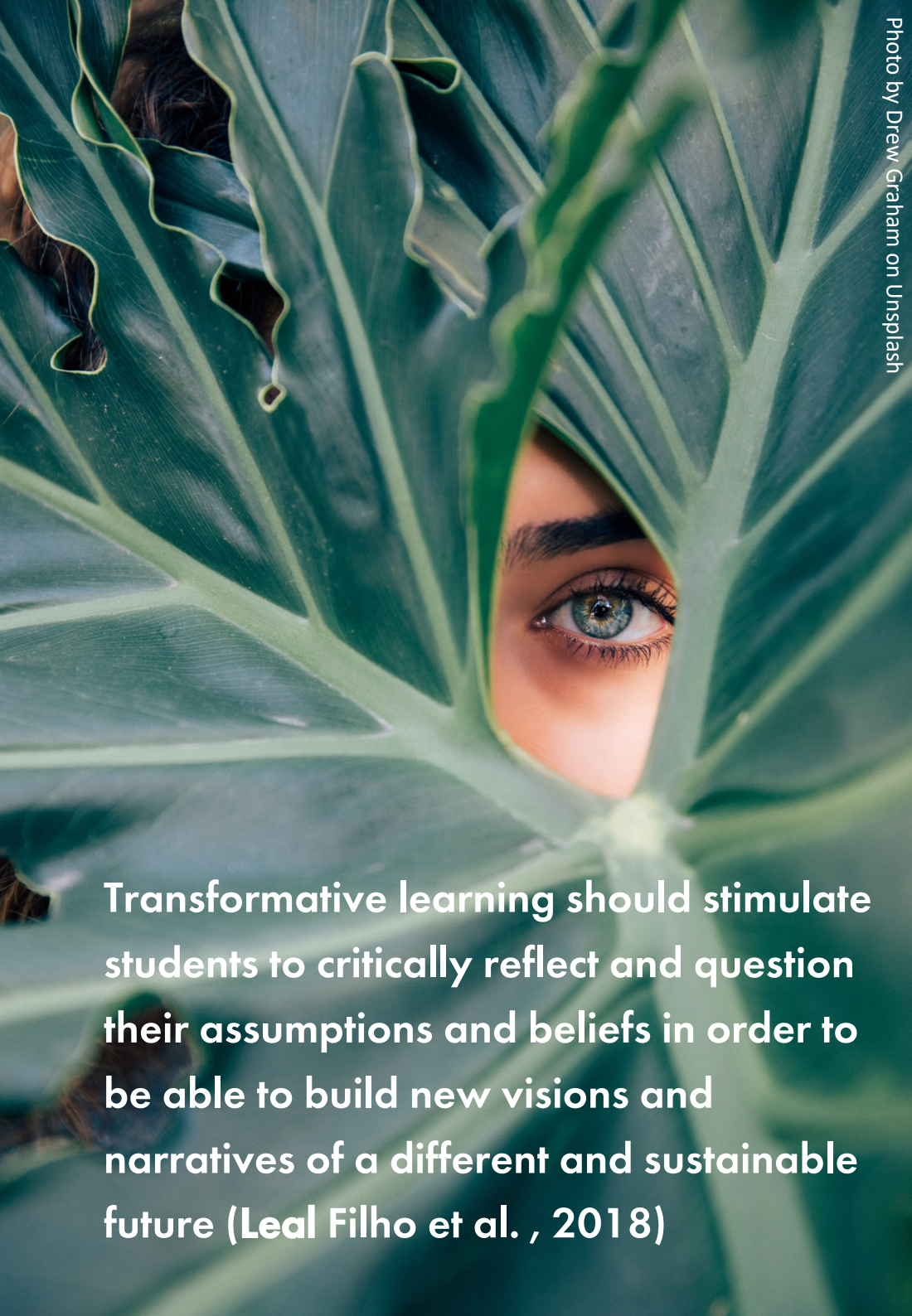


Photo by Drew Graham on Unsplash

Transformative learning should stimulate students to critically reflect and question their assumptions and beliefs in order to be able to build new visions and narratives of a different and sustainable future (Leal Filho et al., 2018)

focus on measurability, emphasising a rationale that promotes solutions that tend to be merely superficial. As an example, Kaufmann et al. (2019) stress proposals for *“different forms of consumption instead of reflecting on why consumption per se (...)”*. Instead of reflecting on why consumption has become *“a crucial part of our notion of the good life”*, ESD discusses alternative forms of the same reality. As such, those rational approaches have been excluding emotions, physical sensations and other experiences from educational processes and they can play an important transformation role in sustainability learning. Kaufmann et al. (2019) argue that transformative learning should not be transformed into a buzzword for ESD and should involve *“a deep, structural shift in the basic premises of thought, feelings, and actions”*. Leal Filho et al. (2018) reinforce the argument by stating that transformative learning should stimulate students to critically reflect and question their assumptions and beliefs in order to be able to build new visions and narratives of a different and sustainable future.

Emerging themes towards transformative learning involve: (i) critical-emancipatory perspectives on education, focusing on the collective reflection and discussion of shared beliefs (Getzin & Singer-Brodowski, 2016), (ii) *“pedagogy of degrowth”* in the context of university education (Prádanos, 2016; Kaufmann et al., 2019), (iii) the inclusion of non-measurable aspects like perceptions (colours, smells, and sounds), physical sensations, emotions, teleological implications and activities, and other experiences that enforce the capability to enjoy, self-acceptance, self-efficacy as well as mindfulness, the quest for meaning and solidarity (Kaufmann et al., 2019), or (iv) the undertaken of participatory pedagogies that promote critical self-reflection and enable to transform habits of the mind (Leal Filho et al., 2018).

The importance of connecting ESD with transformative learning is that community engagement and the ability to deal with complexity and uncertainty are pursued (Ryan & Cotton, 2013). *“In this new reality, universities should operate as knowledge and reflection institutions developing critical thinking and not only as teaching institutions that transfer knowledge”* (Leal Filho et al., 2018). This demands and leads to innovation in pedagogical methodologies (Ortega Sanchez et al., 2018).

3.2. Mapping sustainability competences and pedagogical approaches within HEI and teaching for sustainability

There has been limited research on the connection between how courses are delivered (pedagogical approaches) and the sustainability competences they might generate (Lozano et al., 2019). Nevertheless, in recent years considerable research has been devoted to both of the concerns in separate.

Regarding competences, the ERASMUS+ project “A Rounder Sense of Purpose” developed a practical framework of competences for ESD, which is schematized in Figure 3. They developed a guide to be embedded into existing programs and off-the-shelf courses with training materials for others to use.

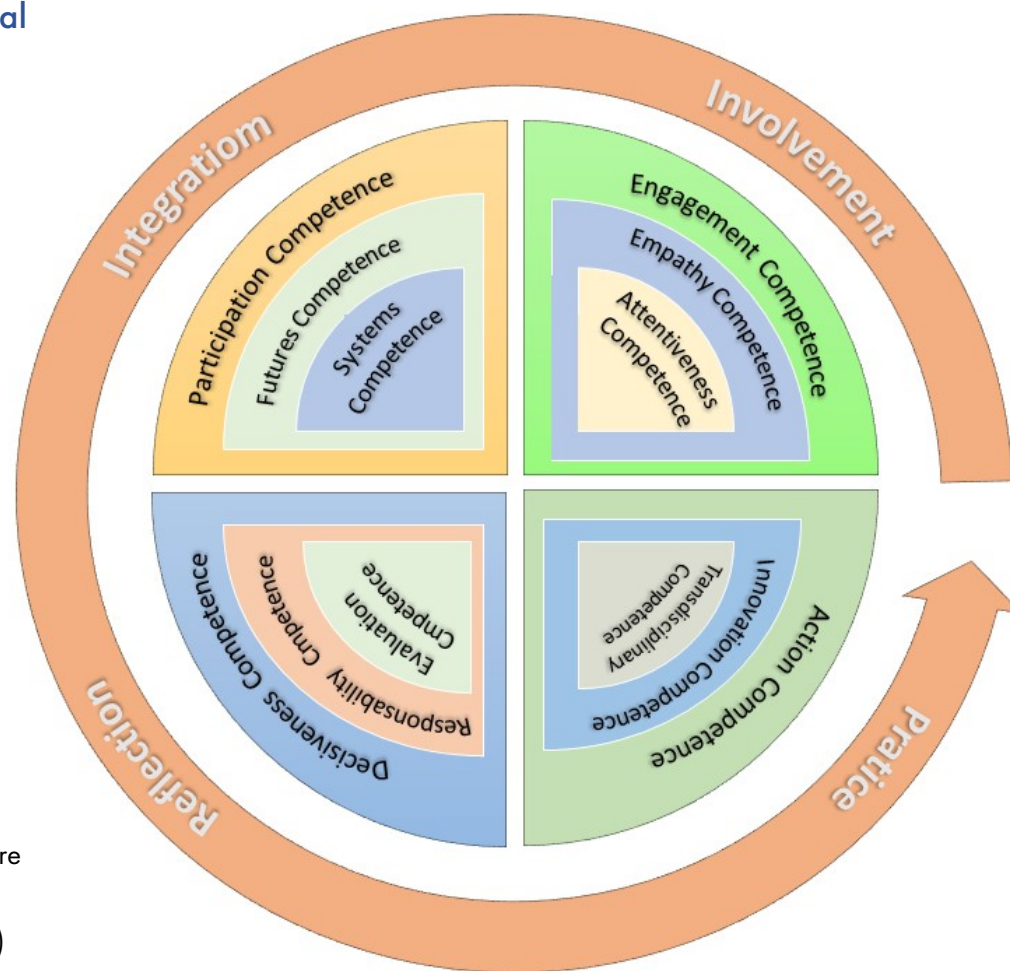


Figure 3. Competences framework for ESD. Adapted from Vare & Millican (2018)
<https://www.aroundersenseofpurpose.eu/uk/home>

Table 4 below summarizes some of the proposed sustainability competences, meaning a way of describing desired educational outcomes for sustainability. Those competences include “cognitive, functional, ethical, and personal dimensions and link complex knowledge, skills, and attitudes” (Lozano et al., 2019).

Table 4. Summary of Education for Sustainable Development (ESD) Competences (Source: Adapted from Lozano et al., 2017, and Vare et al., 2019)

Sustainability Competences	Aims	Description and principles	References
Systems-thinking and handling of complexity	Help learners to develop an understanding of the world as an interconnected whole and to look for connections across the social and natural environments and consider the consequences of actions	<ul style="list-style-type: none"> - Analysis of complex systems across different scales and domains of inquiry - Empirical verification and articulation of a system's key components, structure and dynamics - Attention to systemic features (e.g., feedback, inertia, stocks and flows, and cascading effects) - Understanding of complex systems phenomena, including unintended consequences, path dependency, systemic inertia, and intentionality - Understanding of connectivity and cause-effect relationships - Application of modelling (qualitative or quantitative) 	Wiek, Withycombe, & Redman, 2011; Rieckmann 2012; Lambrechts et al., 2013; Lozano et al., 2017; Vare et al., 2019
Anticipatory thinking or futures thinking	Help learners to explore alternative possibilities for the future and to use these to consider how behaviours might need to change	<ul style="list-style-type: none"> - Envisioning, analysis and evaluation of possible futures, including scenarios with multi-generational timescales - Application of precautionary principle - Prediction of reactions and dealing with risks and changes 	Wiek, Withycombe, & Redman, 2011; Rieckmann, 2012; Vare et al., 2019; Lambrechts et al., 2013
Normative competences	Help learners to collectively map, specify, apply, reconcile and negotiate sustainability values, principles, goals and targets	<ul style="list-style-type: none"> - Assessing the (un)sustainability of current and/or future states of social-ecological systems and collectively creating and crafting sustainability visions for these systems - Acquiring normative knowledge (concepts of justice, equity, social-ecological integrity and ethics) 	Wiek, Withycombe, & Redman, 2011
Strategic competences	Help learners to collectively design and implement interventions, transitions and transformative governance strategies toward sustainability	<ul style="list-style-type: none"> - Ability to design, implement interventions, transitions and transformations for sustainability - Active and responsible engagement in sustainability innovative projects and activities - Development and application of ideas and planning and executing projects/strategies - Ability to reflect on, and deal with, possible risks - Organization, leading and controlling processes, projects, interventions and transitions - Identification of scopes of creativity and participation - Taking responsibility for motivating others 	Rieckmann, 2012; Wiek, Withycombe, & Redman, 2011; Lozano et al., 2017
Interpersonal competences	Help learners to work responsively and inclusively with others, remaining aware of their personal beliefs and values	<ul style="list-style-type: none"> - Participatory and collaborative approaches to solving problems or conducting research - Skills and understandings in deliberation, negotiation, empathizing, leadership and collaboration - Ability to deal with conflicts and learn from other perspectives - Participation in community processes and cooperation in (heterogeneous) groups 	Rieckmann, 2012; Wiek, Withycombe, & Redman, 2011; Lozano et al., 2017; Vare et al., 2019
Critical thinking and analysis	Help learners to evaluate critically the relevance and reliability of assertions, sources, models and theories	<ul style="list-style-type: none"> - Ability to challenge norms, practices and opinions - Reflection on one's own values, perceptions and actions - Understanding of external perspectives 	Rieckmann, 2012; Lozano et al., 2017; Vare et al., 2019

Table 4. Summary of Education for Sustainable Development (ESD) Competences (Source: Adapted from Lozano et al., 2017, and Vare et al., 2019)

Sustainability Competences	Aims	Description and principles	References
Empathy and change of perspective	Help learners to develop their self-awareness and their awareness of others	<ul style="list-style-type: none"> - Ability to identify own and external perspectives - Ability to develop emotional intelligence (transcultural understanding, compassion) - Understanding and sympathy for the needs, perspectives and actions of others - Ability to deal with internal and external value orientation - Compassion, empathy and solidarity with others across differences, transcultural understanding - Accepting and embracing of a diversity of opinions, experiences or perspectives 	Rieckmann, 2012; Lozano et al., 2017; Vare et al., 2019; Lambrechts et al., 2013
Transdisciplinary work	Help learners to act collaboratively both within and outside of their own discipline, role, perspectives and values	<ul style="list-style-type: none"> - Appreciation, evaluation, contextualization and use of knowledge and methods of different disciplines - Ability to work on complex problems in interdisciplinary contexts 	Rieckmann, 2012; Lozano et al., 2017; Vare et al., 2019
Communication and use of media	Help learners to understand the use and impact of different information and communication technologies	<ul style="list-style-type: none"> - Ability to communicate effectively in intercultural contexts - Ability to use appropriate information and communication technologies - Critical consideration and evaluation of media 	Rieckmann, 2012; Lozano et al., 2017
Assessment and valuation	Help learners to understand the importance of and the differences among evaluation frameworks	<ul style="list-style-type: none"> - Develop assessment and evaluation standards and guidelines - Independent evaluations of conflicts of interest and goals, uncertain knowledge, contradictions 	Rieckmann, 2012; Lozano et al., 2017
Justice, responsibility, and ethics	Help learners to understand philosophical perspectives on ethics, social justice and community-building	<ul style="list-style-type: none"> - Application of concepts of ethics, justice, social and ecological integrity and equity - Description, negotiation and reconciliation of principles, values, aims and goals for sustainability - Responsibility for one's actions - Ethics and sustainability of personal and professional behaviour 	Lambrechts et al., 2013; Lozano et al., 2017
Personal involvement	Help learners to take action in a proactive and considered manner	<ul style="list-style-type: none"> - Participation in creating sustainability initiatives - Willingness and ability to acting fairly and ecologically and to learn and innovate - Self-motivation - Initiation of own learning 	Rieckmann, 2012; Lambrechts et al., 2013; Lozano et al., 2017; Vare et al., 2019
Tolerance for ambiguity and uncertainty	Help learners to act in a cautious and timely manner even in situations of uncertainty	<ul style="list-style-type: none"> - Coping with conflicts, competing goals and interests, contradictions and setbacks - Leading with ambiguity and frustration tolerance 	Rieckmann, 2012; Lozano et al., 2017; Vare et al., 2019

Regarding pedagogies for sustainability, it is critical to understand the usage and the effectiveness of different pedagogical approaches. According to Lozano et al. (2019) *“pedagogy is defined as ‘the art or science of teaching’ and the choice of pedagogical approaches depend on each particular pedagogical and educational goals, target group (students, teachers or administrative staff), learning environment and other contextual factors”*. Leal Filho et al. (2018) stress that the individual values of academics influence the content, learning outcomes and pedagogy used in teaching.

Lozano et al. (2019) refer that lecturing remains a *“standard approach to instruction in HEI, so much so that many professional instructors are identified as ‘Lecturers’, and many new instructors rely heavily on such didactic approaches because they believe this to be the expected norm in higher education.”* However, lecturing may not be the most effective approach for a transformative learning for sustainability (Lozano et al., 2019).

Cotton and Winter (2010) and Lambrechts et al. (2013) are some of the authors that explore different educational techniques that can be used in the field of sustainability: roleplay and simulations, games, group or personal diaries, group discussions, stimulus activities (watching a video or looking at photos, poems or newspaper extracts to initiate reflection or discussion), debates, peer assessment, critical incidents (students are given an example and asked what they would do, what they could do, and what they should do), reflexive accounts, personal development planning, critical reading and writing, bibliographic research, fieldwork, and modelling good practice or internships.

Kapitulčinová et al. (2018) analysed an interesting tool - the Accelerator toolset - given its participatory and engaging features, particularly relevant for sustainability efforts at HEIs, that has been applied in some HEIs with still few discussions in academic writings. Apart from its relative simplicity and flexibility, one of the key strengths is that it appears to be a tool with a very strong human dimension by creating engagement and *“fun”* among people.

As Disterheft et al., (2016) highlight, *“fun and celebration”* can be classified as one of the critical success factors in participatory processes relating to SD in HEIs. In the authors' words: *“... it has become increasingly recognized that fun and celebration of achievements along the process, even the most little ones, are an important pillar for transformation in the long-term perspective because ‘if it is not playful, it is not sustainable”* (Dragon Dreaming International, 2014, cited in Disterheft et al., 2016, p. 176-177; Kapitulčinová et al., 2018). Table 5 summarizes some education pedagogies useful for sustainability.

Table 5. Summary of education pedagogies useful for sustainability

Classification	Education Pedagogies for sustainability	Description	Advantages and Challenges	References
Universal	Case studies	Qualitatively rich descriptions of settings, problems and controversies in SD	<ul style="list-style-type: none"> - Challenge students to interact with the inherent complexity and uncertainty found in global, regional, and/or local contexts - Invite students to consider real-world examples and examine issues from a diversity of stakeholder perspectives - Provide a detailed example of opportunities for students to engage in research with complex human-environment systems 	Lozano et al., 2017; Ceulemans & De Prins, 2010; Lambrechts et al., 2013; Cotton & Winter, 2010; Kapitulčinová et al., 2018
	Inter-disciplinary team teaching	Team-taught courses	<ul style="list-style-type: none"> - Allow for the possibility of having specialists in different fields - Help students explore interdisciplinary and transdisciplinary topics from two or more distinctive disciplinary perspectives - May have difficulties in reaching an agreement about content and direction of courses 	Lozano et al., 2017
	Lecturing	Structured lecturing with the use of videos, brainstorming, teamwork, assignments or oral presentations	<ul style="list-style-type: none"> - Useful to introduce subject material and concepts - Skilled lecturer with deep subject knowledge can serve as a role model to students as novice academics, with a fusion of excitement, discovery and mastery that creates expertise 	Lozano et al., 2017; Ceulemans & De Prins, 2010
	Mind, cognitive and concept maps	Graphically represent relationships between ideas, non-linear outline of a central key idea, with related themes radiating out from it, may include short phrases/pictures to represent separate points, use colour, size, connecting line style, and placement to communicate other relationships	<ul style="list-style-type: none"> - Improve student retention of factual information, provided that students retain motivation to use them as a study tool - Results indicate a better understanding of sustainability in courses in which more community-oriented and constructive-learning pedagogical approaches were employed 	Lozano et al., 2017; Lambrechts et al., 2013
	Project or Problem-based learning	Students typically work in self-directed, collaborative groups (sometimes between institutions and even on multiple continents) and may engage stakeholders in community, organizational or business partnerships to address problems through inquiry under conditions similar to professional consultation	<ul style="list-style-type: none"> - Emphasize the value of working on complex, real-world problems for students to develop knowledge, skills and competences, particularly when the problems/projects represent interdisciplinary sustainability challenges - May also overlap with case studies as another form of inquiry-based learning 	Lozano et al., 2017; Ceulemans & De Prins, 2010; Lambrechts et al., 2013; Cotton & Winter, 2010; Kapitulčinová et al., 2018

Table 5. Summary of education pedagogies useful for sustainability

Classification	Education Pedagogies for sustainability	Description	Advantages and Challenges	References
Community and social justice	Community Service Learning	Students engage in activities intended to directly benefit other people, where the activities are integrated with learning activities in an intentional and integrative way that benefits both the community organization and the educational institution. The settings, experiences, levels of engagement and learning potential can vary widely from mere participation in some typical volunteer work with limited problem solving and community interaction to prolonged collaboration on a complex project.	<ul style="list-style-type: none"> - Community service learning has the potential to transform student worldviews. - May contribute to improve students' responses to uncertainty, reflexivity on their own learning and awareness of multidimensionality in considering social problems. 	Lozano et al., 2017; Lambrechts et al., 2013; Kapitulčinová et al., 2018
	Jigsaw/Interlinked Teams	Cooperative peer-learning method developed to help reduce racial tension in desegregated classrooms. Students are assigned to develop expertise in different sub-topics. Then students with expertise in each sub-topic are assembled to create a new 'jigsaw' learning team. In the jigsaw team, each student will be the only expert in each topic and is expected to teach that topic to her jigsaw teammates and learn the other topics from these jigsaw teammates to construct a complete picture of the entire topic. A broader, interlinked team approach has every student assigned to 2 small teams for parallel projects or research topics, developing expertise in each team that is shared with the other team.	<ul style="list-style-type: none"> - Improve students' confidence, interest and affective engagement self-reports in physics, while yielding little difference in exam achievement. - Students performed better in their assigned area of expertise but worse in areas in which they relied on peer instruction than did students in traditional instructional conditions. 	Lozano et al., 2017; Ceulemans & De Prins, 2010
	Participatory Action Research	Similar to action learning in its communitarian philosophical approach and cyclic, reflexive nature. Emphasizes the collaborative nature of research and production of knowledge by all participants, especially those non-academic community members who would be considered 'research subjects' in more mainstream research. It comes from approaches of transformative critical inquiry and emancipatory pedagogical approaches.	<ul style="list-style-type: none"> - Can be a powerful method for improving at-risk student persistence in higher education. 	Lozano et al., 2017; Kapitulčinová et al., 2018
Environmental Education	Eco-justice and community	Shifting from mechanistic and industrial metaphors to metaphors rooted in living ecology and biological systems. It includes a significant emphasis on diversity, relationships, autopoiesis (self-creation) and non-linearity that are characteristic of complex adaptive systems. This pedagogy has 3 main topical foci for critical consideration: (1)	<ul style="list-style-type: none"> - Involves a deep philosophical transformation of mindset of the instructor and students. 	Lozano et al., 2017

Table 5. Summary of education pedagogies useful for sustainability

Classification	Education Pedagogies for sustainability	Description	Advantages and Challenges	References
		Environmental racism and class discrimination; (2) Recovery of the non-commodified aspects of community, and (3) Responsibility to future generations.		
	Place-based environmental education	An approach that seeks to connect scientific understanding and emotional attachment with a specific geography under investigation. It generally focuses on outdoor experiential learning and the specificity of locality and bioregion and is typically multidisciplinary.	- Experiential teaching and learning that provides people with contextual experience and knowledge, cultivating a richer sense of place in students.	Lozano et al., 2017; Kapitulčinová et al., 2018
	Supply chain/Life Cycle Assessment (LCA)	While LCA generally applies to detailed technical evaluations of impacts conducted by professionals under international guidelines, simplified versions can be a valuable learning experience for students. This requires accessing and interpreting data from a variety of disciplinary sources.	- Challenge students to consider sustainability through the lens of a specific product or commodity, understanding its economic, social and environmental backgrounds, contexts and effects.	Lozano et al., 2017
	Traditional ecological knowledge	Long-term knowledge of complex local ecosystems is a powerful tool for conserving biodiversity, often providing valuable deep-time information that is inaccessible in the shorter timeframes of western scientific research projects. By highlighting indigenous knowledge systems and values, instructors and students can also help to sustain threatened cultural diversity and heritage.	- Provide opportunities for students to consider the ways that socio-ecological systems are integrated into specific cultures. - It can be especially beneficial for students from indigenous communities, who may feel alienated or unrepresented by colonial approaches to knowledge about their local bioregion. - It benefits non-indigenous students by opening the possibility to encounter and understand other cultures and worldviews.	Lozano et al., 2017
Transformative sustainability learning	Disorienting dilemma	Experiencing real utopias (e.g., 1-week workshop in which a group visits existing niches in the field of solidarity economy); use of theatre or theatrical workshops as a vehicle-aid for participants in acknowledging the complexity and emotional impacts of the questions raised and for open up group opportunities to experiment new possibilities of referring to the world.	- Strengthen psychological resources and emphasize the political in educational processes.	Kapitulčinová et al., 2018; Sipos et al., 2008; Kaufmann et al., 2019
	Summer schools	4-day events with a specific theme like “Skills for System Change” or “Utopias”; the relevance of the environment in which learning takes place.	- Intensive sharing in a short period within a particular setting - Contains a strong transformative potential.	Kapitulčinová et al., 2018; Sipos et al., 2008; Kaufmann et al., 2019

Recent proposals built on theories of transformative learning agree that *“education has the potential to support individual and collective reflection processes that can ultimately lead to a change in individuals’ internalized worldviews”* and therefore argue for collective and critical reflection of shared beliefs for the development of sustainable futures in and through education (Kaufmann et al., 2019).

However, practice shows that traditional lectures have been widely utilized in higher education to convey sustainability content and few alternative pedagogical approaches have been explored (Lozano et al., 2019). Leal Filho et al. (2018) also point out that academics need to rethink the organizational learning process to enhance students’ understanding of the drastic consequences for human life resulting from the overexploitation of a planet with finite resources. While the environmental (biophysical) dimension of sustainability has been traditionally overemphasized in SD curriculum integration, a more holistic cultural-based approach should further encourage the understanding of the underlying causes of the unsustainability of current trends, such as the political or cultural dimensions of Earth overexploitation.

Therefore, the next part specifically details the conclusions taken from the application of the concept of Ecological Footprint to several University contexts and using different methodological approaches. While Ecological Footprint mainly underlines an environmental dimension of sustainability, it provides a key opportunity to discuss issues about equity and justice (e.g. intergeneration and intrageneration equity), to understand the interlinkages between and interdependence of environmental, social, institutional and economic issues, and to connect to our daily lives and behaviours, leading to a more comprehensive and practical realization of sustainability challenges.

“Education has the potential to support individual and collective reflection processes that can ultimately lead to a change in individuals’ internalized worldviews.” (Kaufmann et al., 2019).





4. Overview of relevant cases on Footprint teaching methods: projects, tools, outcomes and challenges.

During the last 15 years, the Ecological Footprint has been used in several teaching exercises, oftentimes following different methods; the outcomes of such pilot cases are summarized in Table 6. These different experiences took place all around the globe and targeted different population segments, enabling wide-ranging conclusions regarding the influence of sustainability education through the use of footprint methods. From kindergarten, to higher education institutions, the results are extensive and share common traits.

The use of Ecologic Footprint Calculators – and primarily of Global Footprint Network’s personal Footprint calculator – is broadly applied in various case studies. Even though its limitations are recognized, it is still one of the most informative tools for creating consciousness among individuals and guiding them through the knowledge-awareness-action journey. Suggestions for calculator improvements have been proposed by a few studies involving direct use by the referred groups, such as augmenting the number of

questions inside each category or leading to a higher precision of the results - which could be beneficial for the user, generating sharper insight on the subject. As investigated by Collins et al. (2020), some of these suggestions have been implemented in a recent update of Global Footprint Network’s personal Footprint calculator while others remain to be addressed. Nevertheless, the common ground among all experiences is that a greater sense of consciousness was generated in those who accessed and used the EF Calculator, as also proved by Collins et al. (2020) through the surveying of approximately 5,000 calculator users. According to this study, after being confronted with the results, 78% of the users revealed a willingness to embrace adjustments in their day-to-day life, particularly on food, water and recycling, and travel choices.

Nonetheless, determining each one’s Ecological Footprint is not enough to presume that patterns of behaviour among society will change. It is necessary to implement these individual changes through a certain range of time to guarantee successful outcomes. Revising educational curricula to incorporate sustainability themes, blended with tools such as the EF Calculator and Footprint Accounts at large, enhance the chances of creating mindful and environmentally aware generations. Adjusting subjects and resorting instruments tailored to particular audiences are critical not only for universities but also to all school levels, from kindergarten to high schools. It is also important to replicate these teaching trials, aiming for more precise conclusions. A wider span of time spent approaching this sort of subject would also be beneficial, bearing in mind that the process of creating awareness and generating effective change is not immediate and the impact of the outcomes takes time to be processed and detected.

The analyzed experiences prove the prominence of quality education in sustainability and its benefits. In order to ensure the success of such projects, some authors believe a longer evaluation is necessary, along with the use of captivating resources and pedagogical tools. Some key insights can be taken from the literature review provided in Table 6.

Table 6. Ecological Footprint application in education: a review

Articles	Objectives	Research question(s)	Participants	Methodology	Results	Suggestions
Venetoulis (2019)	Emphasizing the ecological importance of consumer habits and categorizing them (revealing the 'hidden' ecological costs of consumption)	How big is the University of Redlands's ecological impact?	Data collection (from 4 teams of students from University's physical plant, Environmental Studies Department's GIS, American Forests, California and US Department of Energy) Redland University, Environmental Studies Department, California, USA	1. Framework of weak, strong, ideal sustainable development (Baker et al., 1997) (ideal: local level of analysis, strong: local to global, weak: country) 2. Campus Ecology Footprint Worksheet (Energy- Powerprint: electricity, natural gas, gasoline, air travel / Water: hydroprint / Wasteprint)	1. University's Ecological Footprint: Transportation (32.45%), Electricity (31.42%), Natural gas (18.66%), Solid waste (12.45%), Water (5.02%) 2. The University of Redlands has begun to take up sustainability and some of the preliminary findings. 3. Used this paper help guide the initial development of several alternatives that would move the campus toward sustainability by changing the design of the building that houses the Environmental Studies, Math, and Physics Departments. 4. Are EF assessment and sustainability important enough to promote awareness about them on college campuses or would campus communities do better without the perspective they provide and the changes they may indicate are needed to move toward sustainability?	1. For those choosing to pursue sustainability, this paper has aimed to help inform these pursuits by sharing some basic ideas about sustainability theory and a practical way to carry out research into significant aspects of a campus' environmental impact. 2. It is difficult to say whether or not rapid advances in energy and other technology can forestall the impacts of the consumption gap. Footprint assessments cannot answer this question. 3. The success of linking sustainability concerns with campus ecology is in part contingent upon an awareness of problems and commitment to ameliorating them so as to be more in line with sustainability aspirations. 4. From a strong or ideal approach to sustainability there are plenty of opportunities for the university to move toward sustainability.

Table 6. Ecological Footprint application in education: a review

Articles	Objectives	Research question(s)	Participants	Methodology	Results	Suggestions
Collins, Galli, Patrizi, & Pulselli (2018)	<ol style="list-style-type: none"> 1. Assessment of students' consumption habits and environmental responsibility, given that consumption choices are prerequisites for designing steps towards sustainable behaviour. 2. Enhancing awareness of the environmental consequences of consumption behaviours. 	<ol style="list-style-type: none"> 1. What size are students' EFs? 2. Do differences exist between students within and between institutions and across programs? 3. What factors may be influencing the scale of student EFs? 4. What types of change are students prepared to make in order to reduce their individual EF? And to what extent are they able to reduce their EF? 5. How valuable do students perceive the EF calculator as a tool for understanding the environmental consequences of resource use? And how can EF calculators be developed further to enhance the student learning experience? 	<p>51 students from both Universities and High Schools (total):</p> <ul style="list-style-type: none"> - 20 students (39%) from Cardiff (UK) - 31 high-school students (61%) from Siena (Italy) 	<p>Global Footprint Networks' personal Footprint (EF) calculator methodology:</p> <ol style="list-style-type: none"> 1. Teaching EF, strengths & limitations of EF 2. Students voluntarily calculated their personal EF (specific instructions). 3. Interactive class discussion on the ways in which EF could be reduced. 4. 2nd interactive class discussion (types of changes). 5. Reflections on the usefulness of EF calculator and ways to improve it. 	<ol style="list-style-type: none"> 1. The average EF per capita ranged from 4.0 to 6.1 gha (higher than the world average EF per capita, 2.8 gha) 2. Categorizing student activities related to EF: Food category (40%), Goods (22%), Services (17%), Mobility (13%) 3. Students could identify possible changes in their day-to-day consumption habits after receiving the educational message from the first round. 4. Students' assessment and understanding of their own EF compared to the world average. 5. Students' personal experiential contact with EF, understanding of its potential and its relevance to sustainability. 6. Incorporating sustainable consumption into students' daily habits. 7. Students demonstrated an ability to quantitatively capture how knowledge and awareness of the environmental consequences associated with certain consumption behaviours may facilitate better choices and encourage commitment to sustainable resource use. 	<ol style="list-style-type: none"> 1. Small sample used in this study, does not allow any statistical analysis, a new research with a larger sample is proposed. 2. Longer (more than one year) and systematic repetition of the experience could be a valuable focus of future research, possibly differentiating results by country, age, gender, educational level and teaching curriculum. 3. Increase the number of questions included in the Goods section of the calculator. 4. Include questions in the Food and Goods sections related to reuse and recycling. 5. Upgrading the EF (e.g., add a "help" button). 6. Longitudinal studies of students EF at the start and end of the same academic year.

Table 6. Ecological Footprint application in education: a review

Articles	Objectives	Research question(s)	Participants	Methodology	Results	Suggestions
Fernandez, Alferez, Vidal, Fernande, & Albareda (2016)	<ol style="list-style-type: none"> To provide a sustainability training for future primary school teachers - by their active participation in a multidisciplinary educational program To lead future primary school teachers to change their consumption habits by increasing their awareness of sustainability through analysing and reducing their EF 	Does the educational training program have an impact on the alumni's consumption habits or awareness of individual habits after the training is complete?	119 students participated in the educational program: 42 students from the 2nd year and 77 from the 3rd year	<ol style="list-style-type: none"> Alumni of Primary Education degree calculated their personal EF online (Planets, global hectares, gha) before the training; their EF was broken down into different categories A semester later, the students re-measured their EF while being exposed to a curriculum, extra-curricular activities and educational resources on environmental, social and educational matters to shape their sustainability attitudes Two focus groups were created: group A (taught on human rights, peace and human security, cultural diversity, etc.); Group B (taught on Natural resources, climate change and rural development). Both groups were taught common subjects. The study compared the two groups: EF (Planets), EF (gha), Carbon Footprint, Food Footprint, Goods and Services Footprint, and Housing Footprint. 	<ol style="list-style-type: none"> Initial diagnosis of consumption habits: there were no statistically significant differences between groups A and B The Food Footprint was the highest contributor to EF for students In Group A, the EF decreased after the teaching activities, but it was not statistically significant, only the Housing Footprint, decreased significantly in this group For Group B, the EF decreased significantly after the training program All the footprints: CF, FF, HF and GSF contributed to the global EF reduction significantly The results show that the students have learned the conceptual content of the subjects, but also have changed their consumption habits It showed their responsibility towards these problems and provide them information on what they could do to alleviate the relevant actions 	NA

Table 6. Ecological Footprint application in education: a review

Articles	Objectives	Research question(s)	Participants	Methodology	Results	Suggestions
Lin (2016)	<ol style="list-style-type: none"> To develop a personal carbon footprint management system in order to improve the determinants of students' low-carbon behaviours. To promote low-carbon concepts. To facilitate carbon management. 	<ol style="list-style-type: none"> Regarding personal carbon footprint, what is Carbon footprint awareness (CFA), the attitude towards it (CFATT), perceived behavioural control (PBC) & subjective norms (SN) (based on environmental behavioural theories)? Finding the determinants of an individual's environmental behaviour (knowledge, awareness, attitude, behavioural control and social norms). What are the teaching interventions and strategies (using PECAFOMS) to reduce the carbon footprint of students? 	66 high school students in two groups of 33 students (A-PECAFOMS, B-CFC); two stage observations (short & long term), Kaohsiung city, Taiwan.	<ol style="list-style-type: none"> Questionnaire: 50 critical questions in 6 categories ANOVA Pearson's correlation methodology strategies of PECAFOMS & Persuasive technology – CFC PECAFOMS: Personal Carbon Footprint Management System Persuasive technology: three roles of computer: tools, media, social actors CFC: Carbon Footprint Calculator 	<ol style="list-style-type: none"> Short-term and long-term effects of PECAFOMS educational tool on students' carbon reduction are significant. PECAFOMS improves students' CFA, PBC, SN on carbon footprint reduction. Students' carbon footprint reduction correlates with their personal carbon footprint attitude (awareness, behaviour). PBC has the highest correlation with carbon reduction. Followed by CFA & CFATT, while SN has the lowest (Pearson's correlation). 	<ol style="list-style-type: none"> Developing strategies to improve students' attitudes towards reducing carbon footprint. Longer term observations should be conducted for at least one year to see how students' behaviours are changed. The use of the PECAFOMS educational tool into more schools in order to evaluate its effectiveness. A carbon Footprint Calculator should be designed to first help users acquire carbon footprint related knowledge and then help them find their own opportunities for carbon reduction.

Table 6. Ecological Footprint application in education: a review

Articles	Objectives	Research question(s)	Participants	Methodology	Results	Suggestions
Südas & Ozeltürkay (2015)	<ol style="list-style-type: none"> 1. Obtaining information about carbon, food, goods, and service usage and consumption amount of university students 2. What is the university students' lifestyle based on Ecological Footprint principles? 	What is the profile of university students in Turkey about consuming resource?	420 university students living in Adana, Turkey	<p>Questionnaire of Ecological Footprint, "Ecological Footprint Quiz"</p> <p>It contains 4 main parts including the statements about the carbon, food, goods and service footprint</p>	<ol style="list-style-type: none"> 1. Questions related to carbon Footprint show that respondent mostly live in "150-200 square meters" home, most of the home is located in the inner city, and electricity is the preferred energy source used in home. 2. Most commonly performed energy saving activities are turning lights off when leaving rooms, drying cloths outside, turning off computers and monitor when not in use. 3. Respondent mostly prefer omnivore diet type in relevance to their food Footprint. 4. 70% of respondents generally live within their means. 5. Respondents don't tend to recycle materials. Paper is the most recycled item, and aluminium is at least recycled materials. 	Offers no educational suggestions besides an overview at the country level to incorporate ecologic footprint and suggestions about the future cross culture research.

Table 6. Ecological Footprint application in education: a review

Articles	Objectives	Research question(s)	Participants	Methodology	Results	Suggestions
Global Footprint Network (2014)	Engage, inspire and empower university students to embrace the biophysical core tenants of the sustainability conundrum.	Acknowledging the sustainability dilemma for human economies in a University Module "improving the quality of human life while living within the carrying capacity of supporting ecosystems". This module consisted of a student-driven exploration into what the optimal material scale is for a national	- Pilot at Cornell University	Different according to educational material or activity. Based on National Ecological Footprint and biocapacity results. Aimed mainly at intriguing students with the right questions than in providing answers.	Educational: keep participants intrigued and curious about all the aspects affecting overshoot: from the biological and physical sciences (Earth science, ecology, resource management, agriculture) to the social sciences (economics, international development, international relations, governance, philosophy and ethics, decision-making).	<ol style="list-style-type: none"> 1. Students provide positive feedback about EF. 2. Students refer to this experience as significantly influencing their professional outlook & possibly their career choices.
Lambrechts & Van Liedekerke (2014)	Discuss the possibilities to use Ecological Footprint analysis as a tool for campus operations, educational purpose, and policy development.	Explore the use of Ecological Footprint in higher education	Stakeholders of Khleuven (Belgium), local policy representatives	<ol style="list-style-type: none"> 1. Face-to-face interview with internal stakeholders of Khleuven, including teachers, administrative and management staff 2. Discussion with the external stakeholders like local policy representative and NGO's through workshop 	<p>Ways expressed by stakeholders:</p> <ol style="list-style-type: none"> a. Students calculate their own personal footprint. b. Involve students in the calculation of the university' EF. c. Use EF results in course to further develop SD awareness initiatives by students. d. Go beyond the mere results of number and global hectares. For instance, taking into account and further elaborating on the notion of boundaries, historical perspectives, and inequality. 	<p>EF should be used and interpreted as:</p> <ol style="list-style-type: none"> 1. A static snapshot giving an indication of the university's impact on the environment at a given moment; 2. A useful framework to further work on key components of ecological impact within the campus operations; 3. An awareness-raising tool to engage staff and students to take initiatives towards integrating sustainability within higher education.

Table 6. Ecological Footprint application in education: a review

Articles	Objectives	Research question(s)	Participants	Methodology	Results	Suggestions
O’Gorman & Davis (2013)	<ol style="list-style-type: none"> 1. Use new teaching materials for a better understanding of environmental issues: arts and humanities 2. Incorporate the concept of sustainability into curriculum priorities (as also a national priority in Australia) 3. Motivating students' thoughts and reactions regarding the "gravity" of their EF. 	<ol style="list-style-type: none"> 1. Education across the lifespan has an important contributory role in guiding the changes required to reduce consumption to sustainable levels? 2. What are the subjects in curriculum that enhance both EF understanding and its decrease by students? 	<p>Students- Queensland University of Technology Brisbane, Australia (1-year graduate diploma, focus on curriculum: arts (including visual arts, performing arts and media studies) and humanities (including history, geography and environmental studies)).</p>	<ol style="list-style-type: none"> 1. Ecological Footprint Calculator 2. Ecological Footprint discussion forum (45 entries by 18 participants) 3. Methodology: three-step analysis process to: familiarize with the data; do a thematic analysis; and provide a synthesis 	<ol style="list-style-type: none"> 1. The results on students' reactions when using EF were: a) initial reactions and reflections, b) leading to individual actions, c) leading to impacts on teaching, d) leading to proposals for social change, e) integrating sustainability and visual arts 2. Conclusions: Emotional engagement required for more embarrassed students; EF is a tool for changing personal habits and consumer choices; Enhance of environmental concern through engaging younger children in hands-on activities; Arts and humanities help self-awareness, world perception, awareness and expression 3. The use of the forum has enabled students to adjust their attitudes and efforts in order to reduce negative environmental consumer habits. 	<ol style="list-style-type: none"> 1. Changed teaching and teachers 2. Transdisciplinary approaches to provide opportunities to raise awareness of sustainability issues 3. Incorporate the concept of sustainability into the curricula 4. Emphasis on sustainability education programs 5. Sustainability must be seen as a social and educational priority

Table 6. Ecological Footprint application in education: a review

Articles	Objectives	Research question(s)	Participants	Methodology	Results	Suggestions
Gottlieb, Vigoda-Gadot, Haim, & Kissinger, (2012)	<ol style="list-style-type: none"> 1. Explore whether the EF is an appropriate tool to raise sustainability awareness 2. Explore direction for minimizing school's 'ecological loads' as changing consumer patterns and collaborating with the larger community 	<ol style="list-style-type: none"> 1. What is the process of integrating the concept of the EF at the high school level? 2. Which are the best ways to analyse school's EF? 3. What is EF' contributions to education for sustainability in schools? 	The 10th grade cohort of students in a public high school in the city of Haifa during the course of the school year 2008-2009	<ol style="list-style-type: none"> 1. Two (2) categories of methodology: <ul style="list-style-type: none"> - Theoretical: based on 'eight dimensions' in order to grasp environmental problems as structural and interdisciplinary problems - Practical: based on questionnaires: <ul style="list-style-type: none"> - 2 groups, 2 times (before, after), 6 variables (EW, PN, PBC, B1, PEB) 2. Experimental group: participated in an environmental education program based on the theoretical and practical aspects of the ecological footprint 3. Ecological Footprint calculator 4. Hypothesis test (ANOVA) 5. Data collection at school 	<ol style="list-style-type: none"> 1. Statistically significant differences between experimental and control groups in variables PBC, PN and BI There were no statistically significant differences in EW and PEB 2. The incorporation of the ecological footprint as an educational tool in high school may provide some predictive indicators of PEB 3. Ecological footprint of the school is 320 gha (2008-2009) 4. The main ecological footprint drivers are as follows: food (38%), energy - electricity (35%), products (19%) and transport (8%) 	<ol style="list-style-type: none"> 1. Developing 'changing consumption scenarios' based on EF results 2. Developing an action plan to reduce school's ecological footprint 3. Indicative suggestions by category: food (fresh food, avoidance of packaged foods), energy (reduction of use of air conditioners in the classroom), transport (feet for up to 2 km and use of public transport for longer distances), paper products and plastics (increase recycling) 4. A 'Green Council' should be established in schools 5. Integration of the EF into the school curricula 6. Further research on a larger sample of participants and more schools 7. The education for sustainability program based on the EF should integrate natural sciences with social sciences content material

Table 6. Ecological Footprint application in education: a review

Articles	Objectives	Research question(s)	Participants	Methodology	Results	Suggestions
McNichol, Davis & O'Brien (2011)	<ol style="list-style-type: none"> 1. Adaption and application of the Ecological Footprint (EF) methodology to an early learning centre 2. Measuring students' consumption habits in order to reduce it 	<ol style="list-style-type: none"> 1. Quantify the environmental impact of a kindergarten by calculating its Ecological Footprint 2. Identify key contributors to the overall EF of the kindergarten 3. Assess how the kindergarten might reduce these impacts 4. How the environmental impact can be reduced across the early childhood education sector by using the EF calculator 5. How this information can be incorporated in early childhood sustainability education 	73-76 children aged between 2,5 - 5,5. Campus Kindergarten (CK) University of Queensland's St Lucia Campus (Brisbane, Australia) (school participates in Sustainable Planet Project)	Data from different sources depending on the consumption category. Some examples: utilities bills (2003-2008) & direct measurements (2009) (total electricity & water consumption), survey ACG & AGO (Apelbaum Consulting Group, Australian Greenhouse Office) (2009) (transport), Australian Bureau of Statistics surveys (1999-2003), & Environmental Protection Agency (EPA) Victoria (2005) (food) questions	<ol style="list-style-type: none"> 1. The total EF of Campus Kindergarten was calculated 2. The consumption categories which had the greatest impact on the overall footprint were food (61%), transport (22%), electricity consumption (15%) 3. Subcategories of transport: by car (69%), by walking or bicycle (27%), by bus (4%) 	<p>Suggestions for reducing the Ecological Footprint:</p> <ol style="list-style-type: none"> 1. Changing curricula and teaching strategies in general 2. Energy-efficient design (easier when building a building) 3. Informing parents about ways to reduce it (e.g., promoting public transport) 4. Environmental knowledge and concern of students (due to the age of pupils the main environmental decisions are taken by their parents) 5. Stimulate new researches focused on environmental education 6. Detailed suggestions by category (e.g., a) for paper consumption, only the 10% used is recyclable; b) establishing a fruit and vegetable garden or a chicken coop, c) alternative ways of packing a school lunch)

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Conway, Dalton, Loo & Benakoun (2008)	To measure University's Ecological Footprint and create scenarios to reduce it	<ol style="list-style-type: none"> 1. What are students' activities with the largest ecological footprint? 2. What are possible scenarios for reducing the ecological footprint, taking into account students' activities? 	<ul style="list-style-type: none"> - Geography classes, University of West Toronto at Mississauga (UTM), Ontario, Canada - UTM participates to "Grow Smart, Grow Green" 	<p>Data gathered from different sources according to consumption category. Some examples:</p> <ol style="list-style-type: none"> 1. Electricity bills 2. Online report – students (transport) 3. Interviews, newspaper archive (materials & waste) 4. Number of bottles and packages from the student club (food) (Data not taken into account summer season and University Library) 	<ol style="list-style-type: none"> 1. Students' involvement with EF helps them become familiar with statistical research and teamwork (collaboration) 2. Despite the limitations of EF, it helps students to better understand environmental issues and make specific suggestions 3. University's Ecological Footprint is 8.744 gha (smaller than Canada's Ecological Footprint: 8.8 gha) 4. Energy consumption is the major influence on the University's EF (69.4%), followed by transportation (16.1%) and food (9.2%) 	<ol style="list-style-type: none"> 1. Highlight the role of the Ecological Footprint in supplying information useful to the decision-making process 2. Three (3) possible scenarios are suggested according to the category of Ecological Footprint: <ol style="list-style-type: none"> a. the use of renewable energy, b. the use of public transport, c. the use of a higher percentage of recyclable paper
Cordero, Todd & Abellera (2008)	To improve climate change education and ultimately promote more sustainable practices within universities and for their students	<ol style="list-style-type: none"> 1. Can action-oriented learning designed around the EF improve university students' understanding of the connection between personal energy use and climate change? 2. What is student's understanding of the following three major areas of climate change science? 	<p>400 college students (1st & 2nd year) - San Jose State University Courses:</p> <ul style="list-style-type: none"> - Meteorology 10: Weather and Climate (a lower-division general education course) - Meteorology 112: Global Climate Change (an upper- 	<ol style="list-style-type: none"> 1. Students' knowledge of global warming & energy use 2. Questionnaire consisted of 39 statements – Answers in a five-element Likert scale (strongly agree, agree, don't know, disagree, or strongly disagree) 3. EF learning activity - EF Quiz 	<p>Students:</p> <ol style="list-style-type: none"> 1. Students who completed a relatively simple action-oriented learning activity designed around their EF, significantly improved their understanding of the connection between personal energy use and global warming. 2. Their concern about global warming is relatively high. 3. They have a rudimentary understanding of the sources and impacts of global warming. 	<p>The EF activity is an example of an effective curriculum design that provides a pathway for enhancing student understanding and possibly altering student behaviour in a manner that promotes deeper learning</p>

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Articles	Objectives	Research question(s)	Participants	Methodology	Results	Suggestions
		<ul style="list-style-type: none"> a. The causes of global warming and ozone depletion. b. The relationship between global warming and ozone depletion c. The link between energy use and greenhouse gas emissions 	division general education course).		<ul style="list-style-type: none"> 4. There is a connection between automobile and factory emissions and global warming (94% correct). 5. They identified CO₂ as a greenhouse gas that comes from the burning of coal and oil (83% correct). 6. Understood that as the Earth warms, the polar ice caps will melt, and sea levels will rise (80% correct). 7. Still retain significant misconceptions concerning climate change. 	
Ryu & Brody (2006)	<ul style="list-style-type: none"> 1. The importance of education for behaviour and habit change, based on the principles of sustainability, using the EF (PBL: Problem-Based Learning) 2. Identify key factors that lead to behaviour and habit change (using EFA: Ecological Footprint Analysis) 	<ul style="list-style-type: none"> 1. Does graduate education on sustainable approaches to development significantly impact sustainable behaviour patterns? 2. What are the major factors contributing to a change in individual levels of sustainability? 	<ul style="list-style-type: none"> - Study group: 22 students - Control group: 28 students from Texas A&M University, USA (3 Departments: Urban Planning, Architecture, Land Development) 	<ul style="list-style-type: none"> - 2 tests: pre-test & post-test - 2 groups: study & control group: - Research tool: 16 questions, 4 categories, of EF Quiz (from a nongovernmental organization, Redefining Progress) - Analysis: multiple regression analysis (to identify the most important factors affecting the change of EF) 	<ul style="list-style-type: none"> 1. Environmental education is associated with behaviours change. 2. Negative Ecological Footprint categories influences are: products and services, housing, food and mobility. 3. Apart from education related to increasing environmental behaviour, very positive role held by teaching techniques (PBL techniques). 4. Small changes in behaviour were made in the categories: mobility, products and services (longer training required). 5. Students who learn with the use of PBL teamwork. 	<ul style="list-style-type: none"> 1. Research should be conducted in more classes, with a greater difference between pre-test and post-test (not just one semester). 2. Research should be carried out in more than one University in the country. 3. Concerning Sustainable Development education, emphasis on experiential teaching techniques (teamwork, field research, case study).

Table 6. Ecological Footprint application in education: a review

Articles	Objectives	Research question(s)	Participants	Methodology	Results	Suggestions
	<p>3. Measuring students' environmental concerns</p>				<p>techniques were more likely to reduce their footprint.</p> <p>6. Students with a high EF are: older adults, living in a larger home, staying away from the University.</p> <p>7. The key determinants of the EF are socio-economic factors (e.g., residence, age, distance from university).</p>	

Overall, most of the studies that have applied the Ecological Footprint within a university setting can be ascribed to two main typologies: (i) studies piloting and testing the usefulness of the Ecological Footprint as an educational tool/approach, and (ii) studies using the Footprint as a tool to help assess and consequently reduce the environmental impact of campuses/schools' operations. However, it should be noted that each assessment tool should be adjusted for particular contexts, reflecting the specific conditions of each sector and case study (Mapar et al., 2020). The study by Lambrechts and Van Liedekerke (2014) is the only one – as far as we have seen in the collected literature – that have looked at both such possible uses of the Ecological Footprint in an attempt to more widely help HEIs practice what they preach.

It becomes then quite interesting to look at the overall feedback and recommendations provided by studies fitting within these two macro-areas of work. Most studies recognized that despite its limitation, the Ecological Footprint helps students better understand environmental issues and come up with suggestions about alternative behaviours. Also, a few common suggestions can then be identified when it comes to both teaching through Ecological Footprint and managing campus operations through it. A list of converging recommendations is provided here below, in which three suggestions are highlighted in bold given their frequent recurrence:

- i) EF assessments of students should last longer, thus allowing for longer periods in between EF assessments and teaching periods;
- ii) **A higher number of students and universities, across multiple countries should be involved in piloting Footprint uses in university settings to derive more solid and representative indications;**
- iii) **Teaching sustainability should increasingly and more predominantly focus on the use of interactive, experiential teaching;**
- iv) Plans should be developed to reduce the impact of schools and campuses, possibly involving multiple actors;

- v) **Sustainability issues should be integrated within curricula;**
- vi) Such integration should happen via a trans-disciplinary approach.

Building on suggestion number iii – which calls for the use of interactive, experiential teaching – it should be noted that several studies acknowledged the key role of Footprint calculators in engaging not only students (Global Footprint Network, 2014) but also staff (Lambrechts & Van Liedekerke, 2014) and facilitating action-oriented learning. So, the intervention of Ecological Footprint calculator could also act as a facilitator to solve the collaborative barriers about the lack of engagement of faculty members in ESD (Decamps et al., 2017) (see also table 1). It is stressed that Footprint calculators offer multiple teaching moments and opportunities that are oftentimes trans-disciplinary.

Given the above, further investigation was conducted on the nature and role of calculators and a short overview is provided here. According to Collins et al. (2020), the majority of articles on calculators published until today have focused specifically on online carbon calculators (e.g., Padgett et al., 2008; Birnik, 2013), with relatively less attention given to personal Ecological Footprint (EF) calculators, thus somehow explaining the relatively short list of articles included in Table 6. Nonetheless, previous studies have compared the few existing Ecological Footprint calculators and identified several positive features such as (i) the inclusion of comprehensive and location-specific questions; (ii) information alongside questions explaining why certain options were 'greener' (i.e., directing individuals to improved choice making); and (iii) enabling users to purchase carbon-offsetting credits (see for instance Franz & Papyrakis, 2011). Collins and Flynn (2015) compared four popular online individual Footprint calculators and found that although all calculators include questions about the main daily activities (food, waste, energy use at home, travel and goods), most of them do not provide methodological background information nor indications about alternative sustainable behaviours. Within this point of view, in terms of a long-term perspective, it is also

important to support students in developing a sustainable identity and self-confidence that their actions can make a difference (Olsson et al., 2020). Franz and Papyrakis (2011) concluded that for calculators to be effective tools for translating environmental concern into public action – and we would argue for them to first build environmental knowledge and awareness – they need to (i) incorporate a detailed description of the methodology used to calculate results, (ii) illustrate the links between individual choices and the aggregated environmental impact, (iii) clearly frame the scale of the problem, and (iv) provide options that demonstrate how to prevent ecological deficits. Collins et al. (2020) have then found that about 74% of the about 5,000 calculator users they have surveyed deem Global Footprint Network's personal Footprint calculator to be "*...more informative than other Footprint calculators*".

Finally, next to the two usual macro-areas of Footprint use with university contexts – support in teaching and guidance in impact reduction – a couple of studies stand out as they looked at the usefulness of the Ecological Footprint as a way to train future teachers. Nonetheless, a unique approach in transferring Ecological Footprint within universities, for both educational and impact reduction reasons, and targeting all the various players involved in the University life (students, teachers, administrative staff and managers) is missing, thus proving the value-added of what the EUSTEPs project aims to achieve, and the set of university actors it aims to engage.



5. Conclusion

Education has gained a central role in the transition to a sustainable world (Collins et al., 2018). Integrating sustainability within HEIs refers to a broad scope of initiatives including pedagogy and learning, academic research, campus management, practices and impact assessment (Decamps et al., 2017). It helps to mobilize more aware citizens on the need changes in the long term, but also to ensure changes in habits of today. It is not enough to demonstrate the impact of the actions if individuals are not informed about how to better conduct.

More training, specialization and awareness are indispensable tools to thrive. Present teaching methods implemented within HEIs still need to build bridges regarding subjects of global interest, such as sustainability, as well as to foster new pedagogies and competences for a transformative learning. Exposing individuals to sustainability matters in a more extensive, self-reflective and interactive ways may lead to changes in organizational culture and individual and collective behavioural patterns. Sustainability implementation and management in HEIs face several barriers that could be taken down by employing new insights and approaches. What is required is innovation rethinking within HEIs both in their internal actions and operations as well as their interaction with

the external environment (Ferrer-Balas et al., 2008). However, it is very challenging to create strategies that stand out and appeal to the academic community. Moreover, executing massive change among HEIs and their courses can be an even greater challenge, since each institution operates differently. Therefore, innovation is the watchword when developing the content and pedagogies of educational modules and the success of the implementation of educational modules relies on partnership and willingness from HEIs.

The development of innovative tools stands as one of the main goals of EUSTEPs project, with a focus on horizontal integration of sustainability in education, on engaging and empowering all university members, on facilitating communication and coordination among different HEIs and on fostering new pedagogical tools. Different contexts generate different mindsets, and when addressing multiple target groups, this project can contribute to a transformative learning process. The development of university-wide, trans-departmental courses allow to engage students, educators and administrative staff with different backgrounds, culture and knowledge. The EUSTEPs project intends to pursue learning tools that can be transposed throughout European universities and be taught in different courses for different target groups, abolishing barriers found in integrating sustainability.

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