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Education for sustainable development in higher education institutions: an approach for effective interdisciplinarity

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Abstract

This paper builds on existing research on education for sustainable development (ESD) to propose a multi-lateral, adaptative approach to ESD within higher education institutions. The work relies on a scoping literature review to identify current approaches to implementing ESD in higher education institutions (HEIs), as well as the institutional impediments facing such approaches. Based on this theoretical foundation, the paper outlines a proposal for a discipline-dependent, multi-lateral approach to ESD to improve current practices, emphasizing the strengths of such an approach to combat current issues with sustainability in higher education institutions. One defining aspect of the proposal is its attempt to facilitate access to ESD for students from all academic disciplines, especially from underrepresented sectors like the humanities, in HEIs. The approach outlined in the paper relies on three interdependent pillars to achieve this goal: stand-alone ESD curricula, interwoven ESD content in existing curricula, and interdisciplinary research initiatives, all of which rely on the extensive involvement of technology and e-learning.

Design/methodology/approach

The work relies on a robust review and analysis of existing literature proposals on the implementation of education for sustainable development (ESD) in higher education institutions (HEIs) to elaborate an integrated approach to interdisciplinarity. Specifically, a scoping literature review is applied, analyzing existing approaches to ESD in HEIs as well as the challenges observed in their implementation. Using this theoretical framework, the paper evaluates the compatibility and efficiency of the approaches currently implemented. Based on this analysis, an integrative approach is outlined, building upon and combining existing proposals.

Purpose

This article seeks to develop an improved and harmonized approach to interdisciplinarity in ESD within HEIs, focusing on maximizing the mobilization of students from all academic disciplines. An attempt is made to reconcile varying strategies for the implementation of interdisciplinary ESD content in HEIs, studying the relative merit and benefit of those strategies and crafting a new approach combining them, where possible.

Findings

Building on existing literature, the article identifies two main trends for interdisciplinarity in ESD in HEIs: integration into existing disciplinary curricula and new, stand-alone ESD curricula. The paper suggests adopting the two approaches simultaneously, in order to reach students from all academic disciplines, especially those with minimal exposure to ESD through their own discipline. Furthermore, the paper stresses that these dual curricula strategies should be combined with further interdisciplinary research initiatives as well as extensive leveraging of technology and e-learning.

Originality/value

The article bridges the gap between diverging visions for ESD in HEIs, harmonizing strategies from the literature to outline a new, multi-lateral strategy. Furthermore, it extensively studies the need for increased engagement into ESD of students from underrepresented disciplines, including the humanities. This engagement has been little addressed in the literature, rendering the proposed approach original insofar as it outlines ways to improve current approaches to ESD in HEIs.

Introduction

The critical need for sustainability in higher education

Sustainable development, initially defined in the 1987 Brundtland Report as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”, has emerged as a necessary pathway to adapting societies to evolving environmental and resource constraints (United Nations, 1987). Human civilization will face significant environmental disasters in coming years as the result of climate change, as has been testified in numerous reports including the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC, 2014). These will provoke major consequences on a societal level, including population exodus, resource scarcity, and falling crop yields (IPCC, 2014). Humankind will require large-scale adaptation and implementation of sustainable practices. This movement will need a significant impetus from influential societal institutions, in particular from the education sector. HEIs play a central role in educating future generations and directing societal policy, illustrating the need for their emergence as leaders in global sustainable development initiatives (Cortese, 2003). Despite this, it has been widely observed by academics that implementation of sustainability in HEIs has been slower than needed (Lozano et al., 2013; Aktas, 2015; Howlett et al., 2016; Berchin et al., 2021). Confronting the challenges of today and implementing sustainable development globally will hence require a continued and improved effort on the part of HEIs (Leal Filho, 2011).

In recent decades, sustainable education programs have gained particular attention as a sector for the implementation of sustainable development in society and in HEIs. Varying terminology has been used in the literature to denote curricula on environment and sustainability (Guerra et al., 2018). Educational programs focusing on environmental awareness and sustainability have been referred to varyingly as environmental education (EE) and education for sustainable development (ESD). The academic consensus states that ESD grew out of EE over time, as emphasis within sustainability shifted from solely environmental questions to include social and economic topics (Pavlova, 2011). Previous literature has addressed the minute differences between the two terms, considering whether they are today distinct or equivalent. Attempts have been made to distinguish EE from ESD based on their scope, claiming that ESD continues to promote broader vision beyond the purely environmental focus of EE (Stevenson, 2006). McKeown and Hopkins (2003) discuss the differences between the terminology and conclude that the concepts designated are complementary. Within the scope of this paper, the two terms are used interchangeably.

In that light, we may define higher ESD as a sector of education and research within HEIs dedicated to developing knowledge on the three pillars of sustainable development, namely environment, society, and economy. Environmental degradation and decreasing natural resources must be answered for by significant societal innovation and more sustainable practices. Higher ESD serves to develop these initiatives by relying on HEIs to educate future generations and promote awareness on sustainability. This thereby creates the human resources necessary for the implementation of sustainable development on a global scale (Cortese, 2003). Higher ESD focuses on curricula, research, and university operations to increase sustainability in HEIs and in society more broadly (Guerra et al., 2016).

The emergence of education for sustainable development in higher education institutions

Sustainable education programs initially gained international attention in the 1970s, with the first mention of such programs occurring at the *Stockholm Conference* in 1972 (Grinsted, 2011). While the conference formally recognized the role of education in environmentalism and conservation, it did so in general terms, without particular emphasis on any level of education. Subsequent engagement, including the Tbilisi Declaration from 1977 and the Brundtland Report from 1987, provoked additional debate surrounding ESD (UNESCO, 1977; United Nations, 1987; Lozano et al., 2011). The Brundtland Report provided a concise definition for sustainable development and emphasized the need for cooperation between nations, as well as for innovative solutions to help implement sustainable development (United Nations, 1987). Following the Tbilisi Declaration and the Brundtland Report, discussions around ESD began shifting to focus particularly on HEIs. The first declaration on ESD specifically targeted at HEIs, *The Talloires Declaration*, occurred in 1990 (Grinsted, 2011). The declaration constituted the first attempt by university leaders to unilaterally recognize the need for implementing sustainability measures within HEIs (University Leaders for a Sustainable Future, 1990). The declaration outlines a ten-point action plan for stakeholder engagement and improved institutional involvement for sustainable education. One year later, in 1991, the *Halifax Declaration* continued this trend by encouraging universities to “enhance the capacity [...] to teach and practice sustainable development principles” (International Association of Universities, 1991). In 1992, sustainability and education occupied a central role at the United Nations Conference on Environment and Development in Rio de Janeiro (United Nations, 1992). Agenda 21, Chapter 36 of the final report of the Rio Conference is dedicated to education and training programs, repeatedly emphasizing the importance of environmental and development awareness (United Nations, 1992). The report also stresses the significance of universities’ involvement in environmental and sustainability education, citing the opportunities for collaboration with the private sector, as well as with governments.

The conclusions of the Rio Conference were reiterated a decade later, at the World Summit on Sustainable Development. A proposal was made to initiate a United Nations Decade of Education for Sustainable Development, which was then ratified at a General Assembly, entering into force in January 2005 (United Nations, 2002; UNESCO, 2014). The objectives of the Rio Conference were again reiterated at the United Nations Conference on Sustainable Development in 2012. The final report of the Rio+20 Conference, titled “The Future We Want”, explicitly promotes education for sustainable development, given that “quality education at all levels is an essential condition for achieving sustainable development” (United Nations, 2012, pp. 59-60). In Paragraph 230, the report outlines a multi-pronged approach to implement ESD, involving “enhanced teacher training, the development of sustainability curricula, the development of training programs that prepare students for careers in fields related to sustainability, and more effective use of information and communications technologies to enhance learning outcome”.

Shortly after the Rio+20 Conference, the United Nations Decade of Education for Sustainable Development concluded with a report titled “Shaping the Future We Want”. A section was dedicated to the role of HEIs in ESD, lauding the improvements in the sector but stressing continuing difficulties due to lacking leadership (UNESCO, 2014). These concerns were taken up in the Agenda 2030 for Sustainable Development created in 2015 by the United Nations (United

Nations, 2015). The Agenda stresses the necessity to involve ESD in all higher education curricula in order to fulfill the Sustainable Development Goals (SDSN, 2015; UNESCO, 2017; Guerra et al., 2020). Three years later, in 2017, UNESCO published a report on learning objectives for Education for Sustainable Development Goals, claiming that “education is UNESCO’s top priority because it is a basic human right and the foundation on which to [...] drive sustainable development” (UNESCO, 2017). Today, research is pursued on the Sustainable Development Goals is pursued extensively by academics worldwide, with a particular focus on issues of local relevance (Salvia, Leal-Filho, Brandli, Griebeler; 2019). Hence over the last decades, ESD has shifted from an afterword in international policy to a keystone of sustainable development initiatives, with a particular focus on HEIs.

The need for interdisciplinarity in ESD

Given that sustainable development is in itself an interdisciplinary sector, spanning the economy, environment, and society, it seems fitting that ESD should also be highly interdisciplinary. There exist minute differences with respect to the terminology commonly used to designate education spanning across disciplines (Aktas, 2015). Such education has been varyingly referred to as “multidisciplinary”, “interdisciplinary”, and “transdisciplinary”. Traditionally, the distinction between the terms lies in the extent of interaction between the fields in question. Multidisciplinarity would imply a weak linkage between fields, while interdisciplinarity would involve stronger integration. Finally, transdisciplinarity would involve the strongest effort to break down barriers between fields and fully involve individuals from various sectors (Klein, 2006; Aktas, 2015). It is beyond the scope of this article to delve into the subtleties of the terminology, given the primary focus here is to emphasize the importance of collaborative and cross-disciplinary work in sustainability. Hereafter, the article will use the term interdisciplinarity, meaning by this the “*process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline or profession*”, per the definition advanced by Klein and Newell in 1997 (Foley, 2020).

International focus on interdisciplinarity in ESD is hardly new. Particular focus on the topic can be traced as far back as the Talloires Declaration in 1990 (University Leaders for a Sustainable Future, 1990; Lozano et al., 2013). The declaration outlines the need to “convene university faculty and administrators with environmental practitioners to develop interdisciplinary approaches to curricula, research initiatives, operations, and outreach activities that support an environmentally sustainable future” (University Leaders for a Sustainable Future, 1990). More recent declarations, including the Graz, Turin, and Abuja Declarations have all reemphasized the need for interdisciplinarity in ESD (Lozano et al. 2013).

This can be explained by the fact that focus on interdisciplinarity within ESD is broadly supported by the academic community. Azeiteiro et al. (2015) claim that “the emphasis of higher education institutions should be to promote interdisciplinary thinking and analysis, which is the basis of [sustainable development], by teaching the more complex interrelations between economic, social and environmental concepts”. Lozano et al. (2013) allege that “proper academic recognition of the importance of multi-disciplinary and transdisciplinary teaching, research and community outreach is essential for speeding up the societal transformations that are needed for sustainable societal development”. Indeed, one of the key impediments today for successful

implementation of sustainable development is the fragmented production of knowledge (Parker, 2010). Interdisciplinarity helps combat this by encouraging knowledge sharing and collaboration between academic disciplines. The promise of interdisciplinarity in ESD is hence twofold. Firstly, it reduces existing deficiencies in knowledge sharing and research by harmonizing approaches between academic disciplines, thereby furthering greater understanding of ESD and improving best practices. Secondly, it improves students' abilities to reason by using information from several fields, thus allowing them to more effectively respond to the challenges of their time.

Interdisciplinarity in higher ESD must rely on two distinct yet profoundly interconnected activities: teaching and research (Aktas, 2015). Interlinking the two allows students to get both theoretical and practical exposure to sustainability work, all the while contributing to broadening understanding of sustainability within the academic community. Howlett et al. (2016) allege that interdisciplinary teaching content, as well as critical thinking and reflection are absolutely integral to ensuring that students are prepared to face the challenges of this time.

Literature review

Factors for the focus shift to HEIs and current implementation approaches

The increasing shift to higher education within ESD may be attributed to three defining factors of HEIs which make them especially attractive to education on sustainability and environment. The first of these is HEIs' critical positioning in character formation and their potential for shaping meaningful changes in sustainability habits. HEIs have a key role in producing the human resources needed for the transition to sustainability (Guerra et al., 2020; Gholami, Saman, Sharif & Zakuan, 2015). HEIs prepare many of the professionals who will make key policy decisions and direct major societal institutions (Cortese, 2003). Furthermore, HEIs also have a trickle-down effect, influencing the learning framework of K-12 education, thereby compounding their effect on the overall educational system (Cortese, 2003). Numerous studies have been conducted in the past examining the role of higher education in prompting sustainable behavior (Meyer, 2015). Torgler et al. (2006) find that education is a determinant for seeking to prevent environmental damage. De Silva et al. (2012) conclude that higher education is a significant factor associated with concern for the environment and sustainable practices. Meyer (2015) builds on these studies and analyzes the potential causal relationship between education level and environmentally friendly behavior. The study uncovers the existence of an evident causal link between the two variables, concluding that increased educational attainment in turn leads to increases in pro-environmental behavior. Taken together, these results suggest that higher education can have a meaningful impact on individual behavior, generating a base of human resources to support the shift towards increased sustainability.

The second factor that explains the shift to higher education within ESD is HEIs' research-intensive nature. Existing reports on ESD have repeatedly emphasized the importance of research in furthering sustainability projects (United Nations, 2012; United Nations, 2015). "The Future We Want", issued at the conclusion of the Rio+20 Conference, highlights the critical need for research and innovation to carry out the principles of sustainable development. Berchin et al. (2021) allege that research is one of the key pillars of HEIs and enables the dissemination of knowledge, thereby promoting societal changes. Research on sustainable development allows for streamlined

processes and better understanding of optimal practices, providing fundamental support to the advances toward sustainable development (Guerra et al., 2020). Pursuing and publishing research helps promote institutional knowledge-sharing and innovation, which in turn enable the implementation of the goals of sustainable development (Berchin et al., 2021). Furthermore, HEIs can simultaneously teach ESD and pursue academic research, contributing to a growing body of international knowledge on sustainability. This has the corollary of enabling students to apply in-class content in research settings, reinforcing understanding of key sustainability concepts (Barth et al., 2014).

A further benefit of HEIs is their network of close ties, both with government, private sector institutions, and with other HEIs. These networks allow for efficient collaboration on large-scale sustainability efforts. Quist and Tukker (2013) allege that sustainability requires significant interlinkage of innovation, learning, and collaboration, resting upon cooperation between government, education, and financial actors. Van de Kerkhof and Wieczorek (2005) argue for a multi-stakeholder learning and collaboration approach to confront the difficulties of the transition to sustainability. However, collaboration does not come from itself and may prove unfruitful if applied without critical reflection (Poncelet, 2001; Fadeeva, 2005). Developing sustainability practices in education requires a well-thought-out effort of multi-stakeholder collaboration. HEIs prove to be the perfect breeding ground for such engagement. International research projects can facilitate cooperation between HEIs and solidify commitment to the implementation of sustainable development. Conferences and organizations between HEIs, like those which produced the *Talloires Declaration* and other similar work, enable large-scale progress on ESD. HEIs already benefit from ties to the private sector and government through research initiatives. Relying on these links and seeking to expand partnerships will allow for continued improvement on ESD initiatives in HEIs.

The complexity of the transition towards ESD requires initiatives to span sectors within HEIs, involving major structural reforms in operations. Howlett et al. (2016) argue for a significant shift in both curricula and pedagogical practice to usher in improved ESD. Guerra et al. (2016) dedicate a paper to developing a Balanced Scorecard strategy map for the implementation and monitoring of ESD initiatives in HEIs. Berchin et al. (2018) argue that implementation of sustainability in HEIs occurs through six principal strategies, namely institutional agendas for sustainability, research, teaching, campus operations, outreach, and knowledge dissemination. Involving these strategies and relying on international conferences enables HEIs to practice ethics, transparency, and interdisciplinarity in their engagement for sustainability.

Impediments to interdisciplinary research

Despite the evident benefits of improving interdisciplinary research in higher ESD, progress has not been as significant as one may hope (Foley, 2020). Interdisciplinary research is confronted with several structural and attitudinal barriers, making it difficult to implement (Kuhn, 2000). Caiado et al. (2018) provide a comprehensive overview of constraints in the implementation of the SDGs. Glied et al. (2007) dedicate a paper to elucidating common issues in interdisciplinary research centers, alleging that such centers suffer from three key challenges: fiscal sustainability, leadership sustainability, and faculty. Fiscal sustainability is difficult due to the need for significant external funding, as well as the complexity of logistical negotiations on space and personnel.

Leadership sustainability is rare as interdisciplinary initiatives are often highly reliant on charismatic leaders willing to work beyond traditional academic departmental boundaries; this provokes sustainability crises when such leaders leave the centers, endangering the viability of the interdisciplinary work itself. Furthermore, faculty-related issues further complicate this as faculty must be willing to operate within the norms of other departments. Language and practices may differ between the disciplines involved, rendering collaboration substantially more difficult. There also exist major structural impediments to hiring and maintaining faculty outside of one specific department, especially in incentive plans and departmental promotion schemes (Glied et al., 2007). Research by Van Rijnsoever et al. (2011) supports these claims, finding that disciplinary work contributes more to career advancement than interdisciplinary work. Leahy (2007) alleges that less specialized and more interdisciplinary researchers are paid less than highly specialized researchers. It seems evident that such structural issues may impede implementation of interdisciplinary work by making it less attractive than mono-disciplinary work.

Another oft-cited consequential issue with interdisciplinarity is the difficulty to publish in academic journals (Pohl et al., 2015). Rafols et al. (2012) provide consequential analysis of the bias in journals against interdisciplinary research work. They conclude that traditional discipline-based journals receive higher rankings than interdisciplinary journals without justification. This demonstrates the existence of a systemic bias in favor of mono-disciplinary research, which then disincentivizes researchers from pursuing interdisciplinary work.

These structural issues in HEIs erode incentives to pursue interdisciplinary research. Instead of delving into collaborative projects, researchers may be deterred by the diminished career and publishing prospects. In the long term, they will choose to conform to departmental expectations and dedicate themselves primarily to mono-disciplinary initiatives (Rafols et al., 2012). Interdisciplinary centers themselves face significant hurdles and can therefore not adequately aid researchers, thereby compounding the difficulty of interdisciplinary work.

Given the dire need for improved interdisciplinary research practices, past literature has provided various policy recommendations for implementation in HEIs. Van Rijnsoever et al. (2011) suggest increased recruitment of women, supporting Leahy's (2007) conclusion that women tend to pursue more interdisciplinary work than their male counterparts. Van Rijnsoever et al. also propose increased recruitment from outside academia, especially from industrial researchers, to promote interdisciplinary work and circumvent traditional departmental rigidity pervasive in academia. Finally, they suggest structural changes in incentive programs – interdisciplinary engagement should be considered in performance assessments, and financial incentives should parallelly be increased (Van Rijnsoever et al., 2011). Given the importance of publishing in academic research, Pohl et al. (2015) also suggest combating the issue through the journals themselves, building on an extensive paper on interdisciplinary research published by the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine (NAS/NAE/IAM, 2005). It is suggested that journals should actively encourage publication of interdisciplinary research results, through special issues or by academics with particular interdisciplinary experience (Pohl et al., 2015; NAS/NAE/IAM, 2005).

Impediments to interdisciplinary teaching

The challenges faced in the implementation of interdisciplinary teaching identified by the literature review are similar to those in research elucidated previously. The principal academic consensus states that teaching in HEIs is still structured within single disciplines (Howlett et al., 2016; Barth et al., 2007; Everett, 2008). However, the highly interdisciplinary and broad-reaching challenges of the twenty-first century require teaching in HEIs to adapt to the times and provide students with resources from a wide array of disciplines. As Sipos, Battisti, and Grimm (2008) explain, “transformative learning in the context of higher education requires major shifts in university structures to enable such critically reflective, inter/transdisciplinary, experiential and place-based learning to emerge”.

Lozano (2010) identifies several key issues currently impeding the implementation of ESD into existing curricula. These include a lack of understanding of ESD on the part of teaching staff, fear that sustainable development is unrelated to their discipline, as well as structural issues including lacking funding and insufficient institutional support. Insufficient knowledge on sustainable development within HEIs is itself a major issue, as staff are unlikely to have received extensive training on ESD (Velazquez, Munguia, and Sanchez, 2003; Lozano, 2010). Jones et al. (2008) observe similar impediments and conclude through a case study on embedding ESD in Geosciences that two main types of obstacles impede the successful implementation of ESD in teaching. The first of these is “internal”, i.e. personal motivation and engagement on the part of professors. Professors are aware that implementing ESD is a requirement due to university directives and are therefore likely to be “paying lip service” to this requirement, without being personally engaged in the endeavor. A case study by Boks and Diehl (2006) confirms this attitude, observing that “staff members and course coordinators responsible for mainstream courses are unlikely to take any initiative to increase attention for sustainability issues in their courses”. If it is indeed often the case that teaching staff lack motivation to implement sustainability content, those who do choose to implement it may do so ineffectively, defeating the purpose of the initiative.

The second major type of obstacles described by Jones et al. (2008) is “external” and involves structural inadequacies. Professors are likely to claim that adapting their curriculum to address questions of sustainability is time-consuming and difficult. This supports Foley’s analysis (2018) that professors are resistant to change and more likely to continue teaching the same curriculum. Furthermore, professors are concerned about the perceived risk of eroding the core curriculum of Geosciences (Jones et al., 2008). The fact that a large amount of content must be covered in existing curricula is frequently mentioned, suggesting that professors are concerned that modifying their teaching will overcrowd their curriculum (Lozano, 2010). Already-packed curricula – especially in sectors like engineering – make it difficult for professors to accept the need to add more content on top of all of the other work (Chau, 2007; Abdul-Wahab et al., 2003). In that sense, ESD may be seen as a threat to traditional disciplinary teaching and obstructed by professors concerned about dedicating time and resources to their area of specialization. If professors resist the implementation of ESD in their respective curricula, logistical barriers will emerge, and universities may be compelled to require ESD content in their teaching. However, if professors are simply obligated to change their teaching approach and content despite being personally uninterested, the quality of the teaching is likely to be degraded. Therefore, a more substantial effort on the part of HEIs is required to inform professors of the benefits of interdisciplinarity ESD content in their disciplines (Jones et al., 2018). Velazquez, Munguia, and Sanchez (2003) also point to a lack of leadership on the part of university administration and

management, impeding on sustainability progress within HEIs. Teaching staff should therefore be provided with concrete assistance and support with adapting their content.

Methods

This paper seeks to address two key questions: *what are the main existing approaches to interdisciplinarity and ESD in HEIs?* And secondly, *where do these approaches fall short and how may they be improved to effectively drive expansion of ESD programs in HEIs globally?*

Similarly to the process followed by Berchin, Dutra, and Guerra (2020), two simultaneous approaches are applied to develop the theoretical foundation for the paper. Key papers are identified using a scoping literature review, and landmark declarations on ESD are identified using a convenience sample method.

Scoping review

In order to understand the nature of current ESD implementation schemes in HEIs, a scoping literature review is applied within the framework of this paper. The scoping literature review method was innovated by Arksey and O'Malley (2005) and subsequently clarified and expanded by Levac, Colquhoun, and O'Brien (2010). The scoping review applied here follows the general process proposed by Arksey and O'Malley (2005). The research question was identified as: *what are the principal current approaches being applied to develop interdisciplinary ESD in HEIs?* Based on this, relevant studies were selected from Google Scholar, Science Direct, and Web of Science databases. Inclusion and exclusion criteria were adopted, using Boolean operators to maximize the breadth of selected studies. Parameters included in the title, abstract, and keywords search included *(higher education OR universit*) AND (sustainab*) AND (interdisciplin* OR multidisciplin*) AND (initiative OR practice OR operation OR action)*.

The initial article search period for the scoping review occurred from July 1st to August 5th of 2021.

We used the following inclusion-exclusion criteria to select papers for the review: English-language publications in peer-reviewed academic journals published in 2010 or later. No geographic criteria were applied in order to give a representative sample of global, as opposed to region-specific, approaches to ESD.

Using this search process, a total of 52 studies were identified. These were then reviewed, and some were subsequently selected based on subjective relevance to the topic of the article. Seminal papers of the ESD literature, including papers published prior to 2010, were also subjectively selected and included in the literature review. In total after elimination of duplicate and irrelevant papers, this approach yielded 39 papers for the scoping review.

Convenience sample of international declarations

International declarations referenced within the paper are outlined by convenience sample based on their nature as landmark declarations. These declarations are used to shed light on the evolution

of the broad aims of ESD within the academic community. The convenience sample is also supported by Lozano, Lukman, et al.'s (2013) analysis on international ESD declarations.

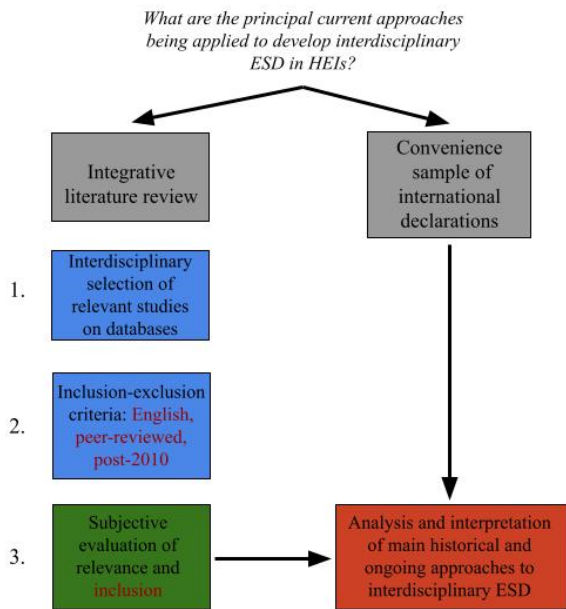


Figure 1a: Steps applied to conduct the integrative literature review

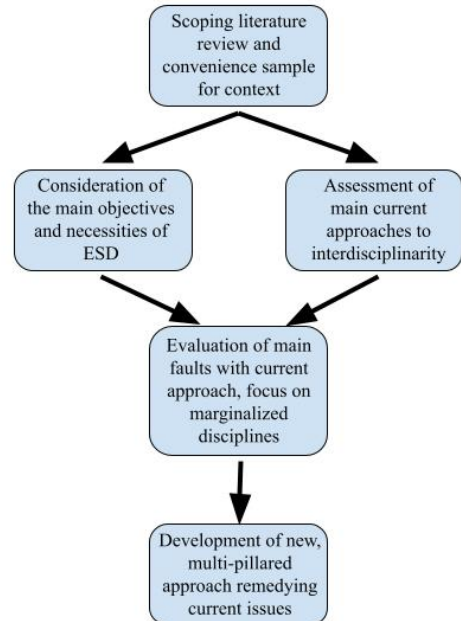


Figure 1b: Steps applied to conduct the paper

Interpretation

Using the results yielded by the integrative literature review, shortcomings of the current approaches to interdisciplinary ESD are analyzed. A new and improved approach is thereby suggested, as seen in Figure 2 included below.

Analysis and discussion: Developing improved practices for ESD in HEIs

Based on the scoping literature review, we identified a variety of ways in which interdisciplinary ESD is being implemented in HEIs. In particular, we classified the main approaches to interdisciplinary ESD in HEIs into two broad types: stand-alone courses and implication in disciplinary curricula.

Current approaches to interdisciplinarity in ESD

The literature points to the existence of variety of current approaches to implement ESD, and specifically interdisciplinary ESD, in HEIs (Berchin et al., 2018). The scoping review allowed us to identify a central debate within the academic community on the ideal nature of interdisciplinarity in higher ESD. Specifically, approaches for interdisciplinarity in ESD within HEIs can broadly be divided into two categories: on the one hand, stand-alone courses on sustainability, and on the

other hand, direct interweaving of sustainability content into existing curricula. Case studies exist in both camps, demonstrating the respective benefits of the two approaches.

Generally speaking based on the observations derived from the scoping review, papers written from the perspective of the applied sciences like engineering advocate for interweaving content into existing disciplinary curricula (see for instance Chau (2005), Boks and Diehl (2006)). This is possible due to the significant overlap with topics of sustainability, facilitating the implication of ESD content into preexisting curricula platforms. Furthermore, it is commonly argued that combining ESD with discipline-specific curricula allows students to acquire highly applicable skills to use in their careers, thereby fostering concrete impact. On the other hand, papers outside of the applied sciences seem to advocate developing stand-alone courses leveraging critical thinking on environmental issues (see Braßler and Sprengler (2021), Howlett et al. (2016), Cortese (2003), Azeiteiro et al. (2015)). Such courses can provide theoretical and practical skills for students from a variety of disciplines but may fail to be as narrowly tailored to students' future career prospects.

Of course, claiming the academic debate relies on only two opposing alternatives of stand-alone courses and integration into existing curricula is reductionist and incorrect. Various attempts have been made to provide more nuanced analysis of current approaches to ESD, developing a more sophisticated categorization of approaches to ESD. For instance, Lozano (2010) provides a thorough analysis this question, alleging that four approaches are currently utilized for the implementation of interdisciplinary ESD teaching. The first of these involves limited coverage of environmental issues in existing courses. The second approach relies on a separate course addressing the issues of sustainable development outside of the existing curriculum. The third approach implies more significant intertwining of sustainable development issues in existing courses, while tailoring the content to the specificity of each module. Finally, the fourth approach is faculty-based, focusing on sustainable development as a potential specialization track for faculty (Lozano, 2010).

Lozano is correct in attempting to distinguish granularly between the different types of interdisciplinary ESD curricula. Nonetheless, the results from the scoping review seem to point to a somewhat more polarized debate, with many papers falling into either the stand-alone category or the interweaving category. Worryingly, existing research emphasizing the complementarity of the two principal camps is sparse. Much of the research provides legitimate claims for one approach or another based on disciplinary constraints but fails to fully address the potential for simultaneously harnessing both approaches to reap the greatest benefit. The paper now attempts to demonstrate the complementarity of the two approaches, crafting a multi-faceted approach to interdisciplinarity in higher ESD.

The forgotten few? Ensuring access to ESD for non-science and social science students in HEIs

The answer to whether to create new courses or modify existing ones cannot be universal, given the stark differences that exist between academic domains and their compatibility with ESD. Designing ESD components to incorporate directly into engineering courses is different than for medicine courses, law courses, or history courses. It is critical to understand the wide diversity of

academic disciplines at play, ensuring that all students are provided with interdisciplinary access to ESD, not just those in science, technology, engineering, and mathematics (STEM) sectors. As the National Center for Educational Statistics (NCES) in the United States alleges, only 18% of the bachelor's degrees awarded during the 2015-2016 academic year were in STEM fields. Focusing solely on implementing sustainability in existing curricula in STEM fields like engineering or even in the social sciences risks overlooking the high proportion of students who should be exposed to ESD but graduate in non-science or social science sectors. Braßler and Sprengler (2021) describe an interdisciplinary course on sustainability they design, which is then made broadly available to students within their university. However, only 5.8% of the students attending the course study the humanities, while 79.75% study social and educational sciences (Braßler and Sprengler, 2021). This dismal statistic exposes the major discrepancies existing between academic disciplines. Students in the applied sciences and the social sciences are likely to gain exposure to sustainability topics either directly embedded into their curriculum or through stand-alone courses on sustainability proposed within their area of study. However, students outside of these disciplines are far less likely to attend such courses due to the distance between their area of study and current ESD.

Combating this lack of access to interdisciplinarity is critical, as all students must be exposed to sustainability content if meaningful societal change is desired (UNESCO, 2017). In order to successfully implement interdisciplinary ESD in HEIs while accounting for the wide diversity of academic disciplines, we propose a three-pronged approach, reaching a wide base of students and providing them with maximal exposure to questions of sustainability.

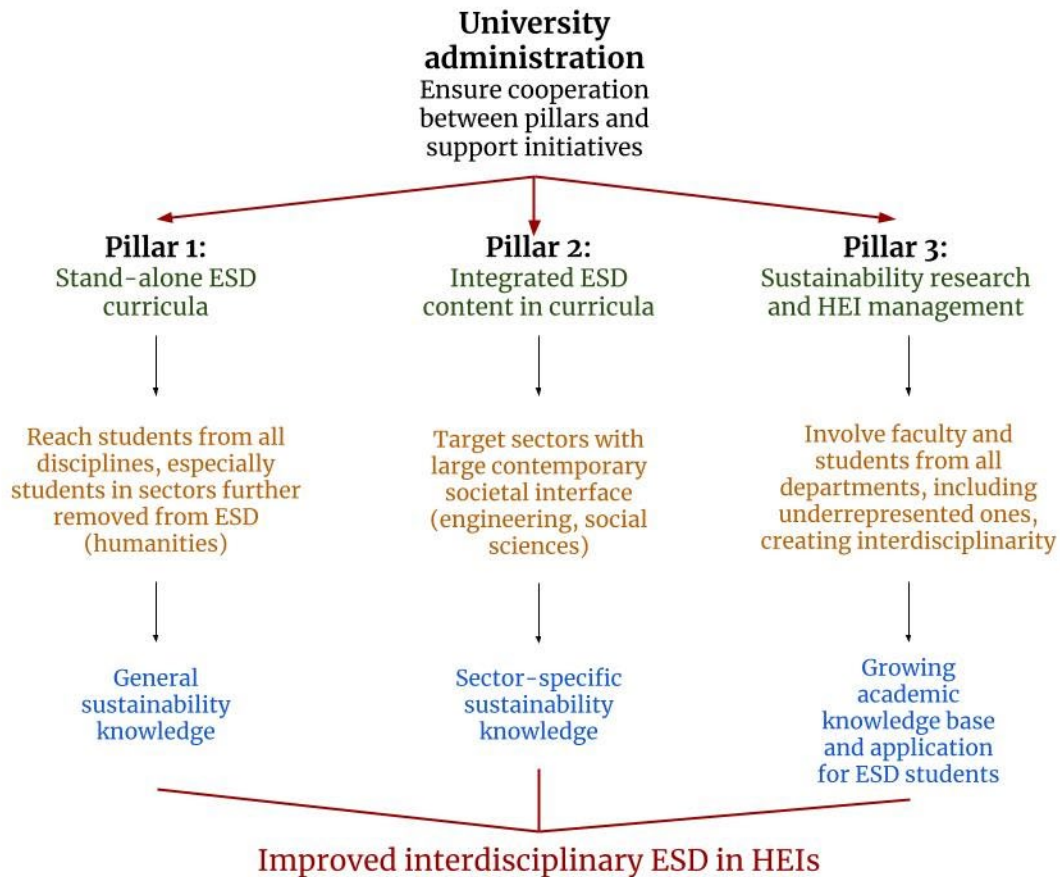


Figure 2: A multi-lateral, adaptive approach to interdisciplinarity in ESD at HEIs

Pillar 1: Widely accessible stand-alone courses on ESD, combined with outreach initiatives

The first of pillar of the approach we suggest is a highly interdisciplinary core curriculum on sustainability, available to all students regardless of their area of study. This curriculum may feature one or several stand-alone courses based on both theoretical and highly practical content on sustainability in society. Proposals for such coursework have been previously submitted in the literature (see Howlett et al., 2016). Braßler and Sprengler (2021) outline an interdisciplinary, stand-alone ESD course available to all students in their university.

Several aspects of the courses are necessary for them to successfully convey the objectives of ESD to students yet unexposed to the concepts. Firstly, the courses should provide highly interdisciplinary insight into sustainability, drawing from sciences, social sciences, and humanities. A course model relying on experts of sustainability giving lectures from different academic disciplines (see Braßler and Sprengler, 2021) may be considered, in combination with smaller tutorials taught by faculty from different departments. This allows students to gain insight into questions of sustainability from outside their own discipline and thereby engage with all three pillars of sustainable development. Secondly, the courses should emphasize reflection and deep learning on the part of students (Howlett et al., 2016). Such approaches allow students to take away knowledge relevant to themselves and their future profession, all the while gathering invaluable

skills like critical reflection. The third key aspect of these stand-alone courses on sustainability is access. The coursework should be made available to students from all academic fields, democratizing access to ESD content and broadening the academic backgrounds of students. In this way, all students may learn to reason with questions of sustainability and thereby improve their practices and example.

Especially important to the success of these courses is their capacity to draw approaches from a wide variety of sectors, in particular from underrepresented sectors like the humanities. While the *content* of these disciplines may seem unrelated to current questions of sustainability, their *approaches* can be invaluable to interdisciplinarity in ESD. The humanities and social sciences are positioned to provide paradigms and perspectives often overlooked in the sciences, (Hensley, 2020; Palsson et al., 2013). Such sectors and their practices promise alternative ways of analyzing and thinking about sustainable development, thereby enriching the content of ESD and providing students with deeper knowledge and understanding (Egan et al., 2004; Hensley, 2020). There is a second benefit of this type of interdisciplinary initiatives: drawing approaches from underrepresented sectors makes ESD more relevant and accessible to students from these disciplines, thereby increasing the likelihood that they will choose to be exposed to content on sustainability.

However, this alone will be insufficient to increase engagement with ESD from students from underrepresented academic disciplines. The interdisciplinary approach we propose for the stand-alone courses on sustainability should be combined with significant outreach and structural reform. Degree programs in all disciplines should be structured to actively promote the stand-alone courses on ESD by facilitating electives and academic credit, or creating enticing pathways within degrees, like minors on sustainable development. University administration may also choose to create informational campaigns advertising the courses to students and encouraging participation in ESD courses and projects. Scholarship and grant programs for work related to sustainability, especially for students from underrepresented disciplines, may be considered to further encourage participation in ESD from a student standpoint. Together, these initiatives ensure that students from domains not directly linked to contemporary sustainability debates will still garner exposure to the essential topics of sustainable development.

Pillar 2: Embedding ESD content into curricula where possible

Of course, continuing the development of stand-alone ESD courses by no means implies that content should not be embedded into curricula directly when possible. The second aspect of our proposed approach relies on sector-specific implementation of ESD content directly into existing curricula, as has been extensively suggested in the literature. Hopkinson and James (2010) provide a pedagogical framework for embedding ESD into STEM curricula. Isenmann et al. (2017) develop a morphological box for ESD to support the modification of existing curricula to conform to ESD. Using existing curricula within strict academic disciplines has the benefit of providing students with sector specific knowledge of sustainability, which is highly relevant to their professional life. Furthermore, this makes ESD content seem more relevant to them and emphasizes the practicability of sustainability from a personal standpoint.

Therefore, when reasonably feasible, for instance in the case of engineering courses, ESD should be woven into current curricula. ESD should be able to prepare students for an active and engaged role in sustainability by providing them with concrete ways to apply their skill set for the benefit of sustainable development. This gives students practical skills in their area of expertise, all the while exposing them to the broader questions of sustainability. This then fulfills the goal of ESD, which should be to expose students to both domain-specific understanding and general procedural knowledge (Boks and Diehl, 2008).

Perhaps a reasonable question would be: *which sectors are appropriate for direct implementation of ESD content into existing curricula?* While it is beyond the scope of this article to engage in a specific classification of sectors appropriate for interwoven sustainability content, a general framework is proposed. The answer to the question framed above is complex and depends on the extent to which major changes in curricula are tolerated. University administration is primarily responsible for pursuing institutional research to understand the viability of academic disciplines for direct embedding of ESD content into curricula. This depends on the type of institution and the specificities of existing curricula, for instance the extent of existing programs with embedded research.

Nonetheless, from a general standpoint, some sectors prove evidently more straightforward for embedding ESD into curricula. Engineering and applied sciences are one such sector, due to their large interface with technology and high potential for developing more sustainable practices throughout society (Abdul-wahab et al., 2003). Sectors containing substantial engagement with contemporary topics in society, economics, or environment are in general promising, as ESD can be implemented within such disciplines as case studies. The social sciences are in especially promising, as they may provide insight into current societal and environmental issues. Disciplines such as government and sociology have potential for contributing to the transnational study of institutional and societal practices with regards to sustainability. Implementing sustainability in business curricula has also been substantially studied, demonstrating that this sector may also be adapted to the requirements of ESD. The disciplines cited previously all warrant involvement of sustainability directly into discipline curricula, due to their engagement with topics of contemporary society.

Nonetheless, the line becomes somewhat murkier in the “pure sciences” and in the humanities, which are at times further removed from contemporary social topics. Realistically, not all sectors are equally well positioned to be modified to discuss sustainable development. Adapting classics or comparative literature curricula to address questions of sustainability, while possible, would require substantial effort and would likely provide somewhat dubious benefit. Therefore, it seems more prudent to instead dedicate resources to expand access for students in these sectors to stand-alone courses on sustainability, as outlined in Pillar 1.

Pillar 3: Continuing the expansion of interdisciplinary research and governance

The third pillar of the multi-lateral, interdisciplinary ESD approach rests on continued pursuit of interdisciplinary research projects, combined with and supported by sustainable governance. This approach should seek to mobilize academics from all types of disciplines, from the sciences and social sciences to the humanities. As Palsson et al. (2013) testify, integrating the humanities and

social sciences into global environmental change research for collaboration alongside the sciences is of critical importance. Berchin et al. (2021) confirm, explaining that research is fundamental to promote advances toward sustainable development, especially through interdisciplinary research centers. These institutions allow academics and universities to gather and share knowledge, thereby contributing to the furthering of sustainability goals. Research initiatives should be supported by democratic practices and sustainability in governance (Berchin et al., 2021). Management should continue to aid departments to engage in sustainability and interdisciplinary research by lifting administrative barriers and providing additional incentives for interdepartmental work (Gled et al., 2007). These actions in turn help facilitate further expansion of sustainability initiatives within HEIs by combating both internal and external impediments to interdisciplinary engagement.

This pillar is tightly intertwined with the pillars previously outlined which focus on teaching. Developing successful interdisciplinary research initiatives on sustainability allows for continued research on better practices of teaching, thereby helping improve the overall sustainability agenda. However, as seen previously, interdisciplinary research also has the major benefit of enabling students to put their skills into practice and expand their knowledge of sustainability further. This could be especially beneficial for students from underrepresented sectors, by allowing them to use their sector-specific approaches in research contexts. In that sense, research centers should be understood as highly interconnected with both Pillar 1 and Pillar 2, as research work on sustainability could be embedded in stand-alone sustainability curricula and in discipline-specific work. Expanding these interdisciplinary research initiatives in ESD hence gives students increased exposure to contemporary academic debates on ESD, while expanding the knowledge base on this topic.

It is also important to note that successful implementation of the three-pronged approach requires efficient interdepartmental communication, as well as effective communication between levels in university hierarchy. There should be effective communication between students, staff, administration, and management to improve collaboration initiatives. University management plays a key role in ensuring that the three pillars perform optimally by fostering effective cooperation between actors. Such a multi-faceted approach also relies substantially on the capacity of HEIs to assess the specificities of their situation and adapt accordingly, implementing strategies which adequately address the issues of their unique positioning. The approach outlined in this paper should be complemented by effective analysis and adaptation, per the morphological approach outlined by Isenmann et al. (2019).

Implicating e-learning in an adaptative approach to ESD

A final key element to this three-pronged ESD approach is using e-learning to the greatest extent possible. Achieving sustainability relies greatly on subsequent generations' capacity to adequately understand and use technology, in particular in the realm of ESD (Pavlova, 2011). This has become especially relevant in recent times: the Covid-19 pandemic exposed the strengths and weaknesses of the current state of e-learning on an unprecedented scale, as tens of millions of students around the world transitioned abruptly from in-person learning to online courses (Wang et al., 2021). Using this knowledge will allow the educational sector to adapt and improve its practices, working towards more efficient and equitable e-learning approaches. Azeiteiro et al.

(2015) provide evidence that implementing e-learning into ESD curricula may be beneficial by providing increased flexibility and adaptiveness to students. Zhang et al. (2020) support this analysis, alleging that self-regulated e-learning can be of benefit to students. Pavlova (2011) suggests that successful implementation of technology education within an ESD framework could provoke deep change in practices, involving both a technical fix and value change. Combining the interdisciplinary courses and research programs with extensive exposure to technology, where justified, will further prepare students for engagement in a digital world. As Berchin et al. (2021) explain, e-learning is a key pathway to the democratization of access to education, in particular in ESD. Expanding its involvement will ensure improved processes, strengthening each of the pillars of the three-pronged approach, and will thereby further the goals of sustainability.

Conclusion

This paper builds on existing literature to propose a combined approach to implementing ESD in HEIs, focusing on the role of interdisciplinarity in this process.

Based on the literature review, the paper identifies a number of impediments to current ESD approaches, both in research and teaching initiatives. The paper discusses the wide variety of approaches currently being implemented in HEIs and identifies a broad debate within the academic community of developing separate ESD courses or interweaving ESD content in existing curricula. Based on analysis of the advantages and drawbacks of these respective approaches, the paper develops a combinatory approach to facilitate the development of interdisciplinary ESD in HEIs.

It is suggested that HEIs should adopt three simultaneous approaches to maximize efficiency in implementation of ESD. First, stand-alone ESD curricula should be developed, taught by faculty from a wide variety of sectors and focusing on highly interdisciplinary content. This approach ensures that students throughout academic sectors are reached by the content and can become more sustainable actors. Second, ESD content should be directly implemented into existing curricula where reasonably feasible, thereby giving students access to both general and sector-specific understanding of sustainability. Third, HEI management should further develop interdisciplinary research initiatives, presenting the possibility for students to get involved and for faculty from across disciplines to collaborate and share knowledge. University management should also attempt to facilitate coordination between these approaches and communication between the different actors (students, faculty, and management). Further attempts should also be made to incentivize sustainability in university practices. All of these approaches should rely on technology to fluidify processes and involve e-learning to the greatest extent possible, where practical.

The implications of this work are far-reaching. Developing a successful approach to ESD is integral to ensuring that future generations are well-equipped to address the economic, social and environmental challenges of their time. Today, interdisciplinary ESD falls short because it fails to reach out sufficiently to marginalized disciplines and ineffectively works across disciplinary boundaries. Giving HEIs and other actors the tools to improve the effectiveness of their ESD programs is a necessary step in the implementation of sustainable development globally. The results of this paper outline a potential pathway for improved ESD and have wide-reaching potential applications.

The results of this paper do present certain limitations. The article does not fully gauge the extent of existing multifaceted approaches and their effectiveness, as opposed to unilateral approaches more commonly implemented in single HEIs. Furthermore, a holistic approach to ESD may not always be logistically possible to implement along the exact lines suggested within the paper. The approach presupposes structural feasibility and institutional willingness to engage with ESD. Lastly, the long-term impact of the pandemic on practices of ESD in HEIs is only tangentially addressed, while this could be beneficial to understand the future trends of ESD. These concerns should be addressed through continued research on the topic.

Future research on the combinatory approach to interdisciplinarity may investigate the specific mechanisms for the implementation of such an approach, focusing on how to effectively incentivize administration and faculty to join such an initiative. Undoubtedly, institutional resistance may emerge to such a logistically complex initiative: how can the benefits be effectively communicated to decisionmakers? Furthermore, attempts may be made to understand the differential nature of current ESD approaches based on geographical location and academic culture. Understanding how to tailor interdisciplinarity to the particular constraints of different locations and institutions will be critical in ensuring the successful implementation of a new approach to interdisciplinarity in ESD.

This paper presents an original proposal for combining various pillars of ESD into a holistic initiative, with the benefit of reaching the entire student body and involving faculty from across disciplines. Continuing research and building on existing work on this topic within the academic community is key to facilitate the transition to a more sustainable future.

Abdul-Wahab, S. (2003). The need for inclusion of environmental education in undergraduate engineering curricula. *International Journal of Sustainability in Higher Education*. <http://dx.doi.org/10.1108/14676370310467140>

Aktas, C.B. (2015) 'Reflections on interdisciplinary sustainability research with undergraduate students', *International Journal of Sustainability in Higher Education*, 16(3), pp. 354–366. doi: 10.1108/ijsh-11-2013-0153.

Azeiteiro, U.L., Bacelar-Nicolau, P., Caetano, F.J.P., Caeiro, S. (2015) "Education for sustainable development through e-learning in higher education: experiences from Portugal", *Journal of Cleaner Production*, 106, pp. 308-319. doi: <https://doi.org/10.1016/j.jclepro.2014.11.056>.

Berchin, I. I., de Aguiar Dutra, A. R., & Guerra, J. B. S. O. A. (2021). How do higher education institutions promote sustainable development? A literature review. *Sustainable Development*, 1–19. <https://doi.org/10.1002/sd.2219>

Berchin, I. I., Sima, S., Lima, M. A., Biesel, S., Santos, L. P., Ferreira, R. V., ... Ceci, F. (2018). The importance of international conferences on sustainable development as higher education institutions' strategies to promote sustainability: A case study in Brazil. *Journal of Cleaner Production*, 171, 756–772. <https://doi.org/10.1016/j.jclepro.2017.10.042>

Boks, C., Diehl, J.C. (2006). Integration of sustainability in regular courses: experiences in industrial design engineering. *Journal of Cleaner Production*. <https://doi.org/10.1016/j.jclepro.2005.11.038>

Braßler, M., Sprenger, S. (2021). Fostering Sustainability Knowledge, Attitudes, and Behaviours through a Tutor-Supported Interdisciplinary Course in Education for Sustainable Development. *Sustainability*. <https://doi.org/10.3390/su13063494>

Caiado, R.G.G., Leal Filho, W., Quelhas, O.L.G, de Mattos Nascimento, D.L., Ávila, L.V. (2018). A literature-based review on potentials and constraints in the implementation of the sustainable development goals. *Journal of Cleaner Production*. <https://doi.org/10.1016/j.jclepro.2018.07.102>

Chau, K.W. (2007). Incorporation of sustainability concepts into a civil engineering curriculum. *Journal of Professional Issues in Engineering Education and Practice*, ASCE. [https://doi.org/10.1061/\(ASCE\)1052-3928\(2007\)133:3\(188\)](https://doi.org/10.1061/(ASCE)1052-3928(2007)133:3(188))

Cortese, A.D. (2003). The critical role of higher education in creating a sustainable future. *Plan. High Educ.* 31, 15-22. Available at <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.739.3611&rep=rep1&type=pdf>

De Andrade Guerra, J.B.S.O., Garcia, J., de Andrade Guerra, M, Barbosa, S.B., Heerdt, M.L., Berchin, I.I. (2016). A proposal of a Balanced Scorecard for an environmental education program at universities. *Journal of Cleaner Production* 172. <https://dx.doi.org/10.1016/j.jclepro.2016.11.179>

De Silva, D.G., Pownall R.A.J. (2014) Going green: does it depend on education, gender or income?. *Applied Economics*, 46:5, 573-586, DOI: 10.1080/00036846.2013.857003

Fadeeva, Z. (2005). Promise of sustainability collaboration – potential fulfilled?. *Journal of Cleaner Production*. [https://doi.org/10.1016/S0959-6526\(03\)00125-2](https://doi.org/10.1016/S0959-6526(03)00125-2)

Foley, H. (2020). Education for Sustainable Development Barriers. *Journal of Sustainable Development*. <https://doi.org/10.5539/jsd.v14n1p52>

Glied, S., Bakken, S., Formicola, A., Gebbie, K., Larson, E.L. (2007). Institutional challenges of interdisciplinary research centers. *The Journal of Research Administration*. Retrieved from <https://files.eric.ed.gov/fulltext/EJ902222.pdf>

- Grindsted, T. (2011). Sustainable universities from declarations on sustainability in Halifax Declaration. *High Educ Policy* 5, 53 (1992). <https://doi.org/10.1057/hep.1992.13>
- Hensley, N. (2020). Re-storying the landscape: The humanities and higher education for sustainable development. *Högre Utbildning*, 10(1), 25-42. <https://doi.org/10.23865/hu.v10.1946>
- higher education to national law. *Environ. Econ.* 2 (2)
- Hopkinson, P. and James, P. (2010), "Practical pedagogy for embedding ESD in science, technology, engineering and mathematics curricula", *International Journal of Sustainability in Higher Education*, Vol. 11 No. 4, pp. 365-379. <https://doi.org/10.1108/14676371011077586>
- Howlett, C., Ferreira, J-A. L., Blomfield, J. M. (2016). Teaching sustainable development in higher education: Building critical reflective thinkers through an interdisciplinary approach. *International Journal of Sustainability in Higher Education*. <http://dx.doi.org/10.1108/IJSHE-07-2014-0102>
<http://dx.doi.org/10.2139/ssrn.2697465>
- Isemann, R., Landwehr-Zloch, S., Zinn, S. (2019). Morphological box for ESD – landmark for universities implementing education for sustainable development (ESD). *The International Journal of Management Education*. <https://doi.org/10.1016/j.ijme.2019.100360>
- Jones, P., Trier, C.J., Richards, J.P. (2008). Embedding Education for Sustainable Development in higher education: A case study examining common challenges and opportunities for undergraduate programmes. *International Journal of Educational Research*. <https://doi.org/10.1016/j.ijer.2008.11.001>
- Leahy, E. (2007). Not by productivity alone: How visibility and specialization contribute to academic earnings. *American Sociological Review*. <http://dx.doi.org/10.1177/000312240707200403>
- Leal Filho, W., Shiel, C., Paço, A., Mifsud, M., Ávida, L.V., Brandli, L.L., Molthan-Hill, P., Pace, P., Vargas, Valeria Ruiz, Caeiro, S. (2019). Sustainable Development Goals and sustainability teaching at universities: Falling behind or getting ahead of the pack? *Journal of Cleaner Production*. <https://doi.org/10.1016/j.jclepro.2019.05.309>
- Leal Filho, W. About the Role of Universities and Their Contribution to Sustainable Development. *High Educ Policy* 24, 427–438 (2011). <https://doi.org/10.1057/hep.2011.16>
- Lozano, R., Lukman, R., Lozano, F.J., Huisinigh, D., & Lambrechts, W. (2013). Declarations for sustainability in higher education: becoming better leaders, through addressing the university system. *Journal of Cleaner Production*, 48, 10-19. <https://doi.org/10.1016/J.JCLEPRO.2011.10.006>
- Meyer, A. (2015) Does education increase pro-environmental behavior? Evidence from Europe. *Ecological Economics*, <https://doi.org/10.1016/j.ecolecon.2015.04.018>
- Munn, Z., Peters, M.D.J., Stern, C. *et al.* Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Med Res Methodol* 18, 143 (2018). <https://doi.org/10.1186/s12874-018-0611-x>
- National Center for Education Statistics. (2019). Status and Trends in the Education of Racial and Ethnic Groups – Indicator 26: STEM Degrees. Retrieved from: https://nces.ed.gov/programs/raceindicators/indicator_reg.asp
- Newell, W.H., Klein, J.T. (1997). *Advancing Interdisciplinary Studies*.
- Palsson, G., Szerszynski, B., Sörlin, S., Marks, J., Avril, B., Crumley, C., Hackmann, H., Holm, P., Ingram, J., Kirman, A., Buendía, M.P., Weehuizen, R. (2013). Reconceptualizing the ‘Anthropos’ in the Anthropocene: Integrating the social sciences and humanities in global environmental change research. *Environmental Science & Policy*. <https://doi.org/10.1016/j.envsci.2012.11.004>

Parker, J.E. (2010). Competencies for sustainability in higher education. *International Journal of Sustainability in Higher Education*. <http://dx.doi.org/10.1108/14676371011077559>

Pavlova, M. (2011). Environmental education and/or education for sustainable development: what role for technology education? Retrieved from <https://core.ac.uk/download/pdf/143904256.pdf>

Pohl, C., Wuelser, G., Bebi, P., Bugmann, H., Buttler, A., Elkin, C., Grêt-Regamey, A., Hirschi, C., Le, Q.B., Peringer, A., Rigling, A., Seidl, R. and Huber, R. (2015). How to successfully publish interdisciplinary research: learning from an Ecology and Society Special Feature. *Ecology and Society*. <http://dx.doi.org/10.5751/ES-07448-200223>

Poncelet, E.C. (2001). "A Kiss Here and a Kiss There": Conflict and Collaboration in Environmental Partnerships. *Environmental Management*. <http://dx.doi.org/10.1007/s002670010130>

Quist, J., Tukker, A. (2013). Knowledge collaboration and learning for sustainable innovation and consumption: introduction to the ERSCP portion of this special volume. *Journal of Cleaner Production*. <https://doi.org/10.1016/j.jclepro.2013.03.051>

Rafols, I., Leydesdorff, L., O'Hare, A., Nightingale, P., Stirling, A. (2012). How journal rankings can suppress interdisciplinary research: a comparison between innovation studies and business & management. *Research Policy*. <https://doi.org/10.1016/j.respol.2012.03.015>

Salvia, A. L., Leal Filho, W., Brandli, Luciana L., Griebeler, Julianne S. (2019). Assessing research trends related to Sustainable Development Goals: local and global issues. *Journal of Cleaner Production*. <https://doi.org/10.1016/j.jclepro.2018.09.242>.

SDSN Australia/Pacific (2017): Getting started with the SDGs in universities: A guide for universities, higher education institutions, and the academic sector. Australia, New Zealand and Pacific Edition. Sustainable Development Solutions Network – Australia/Pacific, Melbourne. Retrieved from https://ap-unsdsn.org/wp-content/uploads/University-SDG-Guide_web.pdf

Sipos, Y., Battisti, B.T., Grimm, K.A. (2008). Achieving transformative sustainability learning: engaging head, hands, and heart. *International Journal of Sustainability in Higher Education*. <http://dx.doi.org/10.1108/14676370810842193>

Torgler, B., García-Valiñas, M.A (2007). The determinants of individuals' attitudes towards preventing environmental damage. *Ecological Economics*, doi:10.1016/j.ecolecon.2006.12.013

UNESCO (2014). Shaping the Future We want – UN Decade of Education for Sustainable Development (Final Report).

United Nations. (2012). United nations conference on sustainable development: The future we want. Retrieved from <https://sustainabledevelopment.un.org/content/documents/733FutureWeWant.pdf>

University Leaders for a Sustainable Future. (1990). The Talloires Declaration. Retrieved from <http://ulsf.org/wp-content/uploads/2015/06/TD.pdf>

Van de Kerkhof, M., Wiezcorek, A. (2005). Learning and stakeholder participation in transition processes towards sustainability: Methodological considerations. *Technological Forecasting and Social Change*. <https://doi.org/10.1016/j.techfore.2004.10.002>

Van Rijnsoever, F.J., Hessels, L.K. (2011). Factors associated with disciplinary and interdisciplinary research collaboration. *Research Policy*. <https://doi.org/10.1016/j.respol.2010.11.001>

Velazquez, L., Munguia, N., Sanchez, M. (2005). Deterring sustainability in higher education institutions: An appraisal of the factors which influence sustainability in higher education institutions. *International Journal of Sustainability in Higher Education*. <http://dx.doi.org/10.1108/14676370510623865>

Wang, X., Li, G., Summaira, M, Anwar, A. (2021). Impact of COVID-19 on achieving the goal of sustainable development: E-learning and educational productivity. *Economic Research-Ekonomska Istraživanja*. <https://doi.org/10.1080/1331677X.2021.1927789>

Zhang, T., Shaikh, Z.A., Yumashev, A.V., Chlad, M. (2020). Applied model of E-Learning in the framework of education for sustainable development. *Sustainability*. <https://doi.org/10.3390/su12166420>