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The patterns of curriculum change processes that embed sustainability in higher education institutions

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Abstract

Implementing education for sustainable development (ESD) in higher education institutions (HEIs) is critical to facilitating a transition toward sustainable development. However, little is known about the specific implementation processes that lead to the institutionalization of sustainability curricula in HEIs. This meta-study and cluster analysis uses 131 international case studies to shed light on six distinct implementation patterns: (1) collaborative paradigm change, (2) bottom-up, evolving institutional change, (3) top-down, mandated institutional change, (4) externally driven initiatives, (5) isolated initiatives, and (6) limited institutional change. A cluster comparison reveals two distinct implementation phases: ESD can be implemented from the bottom-up, from the top-down, or both, and the impetus can stem from manifold external or internal stakeholders. To achieve more comprehensive ESD implementation, open communication among all stakeholders should be facilitated and feedback as well as reflection encouraged. Maintaining a unified vision statement and active participation of all stakeholders fosters a sense of ownership in ESD implementation and ensures that it will be long-lasting. Collaboration between isolated ESD initiatives and various stakeholders leads to shared knowledge and resources. Strong informal collaboration and communication can compensate for a lack of formalized leadership support from the top. Moreover, thorough planning that involves creating a strategy with detailed steps, and balancing shared responsibilities among internal stakeholders further enables fuller implementation of ESD. This analysis represents a first synthesis of small-N case studies and facilitates a better understanding of sustainability curriculum implementation patterns, which are shared in different contexts. Most HEIs and practitioners can benefit from these findings by reflecting on the specific implementation pattern with which the most overlap is found and focusing on this pattern's most pertinent drivers.

Keywords Higher education · Universities · Education for sustainable development · Implementation pattern · Curriculum change · Meta-analysis

Introduction

Higher education institutions (HEIs) are critical to facilitating a transition toward a sustainable society and environment (Orr 2004; Sachs et al. 2019). One contribution of higher education can be the creation of a brighter future through the education of students (the decision-makers of tomorrow), thereby providing them the opportunity not only to develop sustainability competencies (Wiek et al. 2011) but also to critically reflect on their values and to apply these values and knowledge to their future employment and lives (Sipos et al. 2008).

In an effort to advance the implementation of education for sustainable development (ESD) in HEIs, strong impetus, support, and policy frameworks have been put forth by the UN Decade for ESD (2005–2014) as well as by the

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subsequent (2015–2019) Global Action Program (GAP) (UNESCO 2016) and—most recently—by the Sustainable Development Goals (SDGs) via sub-target SDG 4.7., which states that by 2030, it is necessary to “ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development [...]” (UN 2015, p. 17). Currently, the Roadmap #ESD for 2030 provides guidance for further implementing ESD in HEIs (UNESCO 2020).

In HEIs, ESD can be integrated at the micro-level through teaching and learning in courses (Roy et al. 2020) and at the macro-level through programs and curricula (Yarime et al. 2012; Acevedo-Osorio et al. 2020). Various (mostly single-) case studies have provided insights into how this integration can be successful. However, exactly how sustainability curricula are developed and how true institutionalization occurs remain unclear.

In the following sections, *implementation process(es) of sustainability curricula* are defined as “[...] the development and implementation of new approaches to teaching and learning (courses, programs, and certificates) in the paradigm of education for sustainable development, and at the same time, the acknowledgement of sustainability as a cross-cutting theme within the existing curricula” (Barth 2015, p. 47). If ESD is defined as *sustainability education* in the sense of Sterling and Thomas (2006), then the core of the sustainability curricula comprises a paradigm shift that is not only reflected in university teaching but also permeates the entire institution. Therefore, throughout this study, connections are also drawn to the three other areas—namely research, outreach, and campus sustainability—and to how these areas relate to teaching activities. In this context, the *implementation process* is defined as being institutional and comprising various internal and external drivers and barriers.

Curriculum change processes are complex and differ significantly from institution to institution in terms of their breadth, depth, and influences. Insights into such complex sustainability curriculum implementation processes build on and synthesize knowledge from various fields and disciplines. The most frequently—albeit not exclusively—mentioned are: theories on general curriculum change (Cuban 1999; Fullan 2007), organizational change and innovations (Kotter 1996; De La Harpe and Thomas 2009; Verhulst and Lambrechts 2015), transformational change (Eckel and Kezar 2003; Kapitulčinová et al. 2018), transition network methodology (Pardellas Santiago et al. 2017; Stephens et al. 2008), social dynamics and cultural change with the growing focus on learning organizations and adaptive vs. progressive change (Hoover and Harder 2015; Gaugh and Scott 2001; Avery and Nordén 2017), and Meadows’ leverage points for intervening in a system (Lidgren et al. 2006; Meadows 1999). Reviews of these theories and their application to

ESD in higher education—inter-alia, those by Hoover and Harder (2015) and by De La Harpe and Thomas (2009)—have provided additional details on the topic.

Among the various theories, five interrelated elements are considered essential:

First, *the type of implementation* of ESD in the curriculum has been conceptualized by various scholars in different ways. Lambrechts et al. (2013) distinguish between a vertical implementation (explicitly focused on sustainability), a horizontal implementation (elements of sustainability are implicitly integrated), and a combined implementation, whereas Barth (2013) emphasizes the differentiation between disciplinary, interdisciplinary, and transdisciplinary implementation approaches.

Second, *the level of depth* of curriculum change has been further elaborated by various authors. Eckel et al. (1999) emphasize the idea that the scope of change can be measured in terms of its depth and pervasiveness, which gives rise to a spectrum ranging from adjustment at one extreme to transformational change at the other. Additionally, Sterling and Thomas (2006) describe four levels of sustainability curriculum change: denial (no change), “bolt-on” (education about sustainability), “build-in” (education for sustainability), and redesign (sustainability education). *Denial* describes no change, “bolt-on” describes sustainability issues that inform disciplinary topics by integrating sustainability into existing courses or program(s), “build-in” describes sustainability that is addressed in interdisciplinary collaboration through new or cross-disciplinary sustainability courses or programs, and *redesign* describes the integration of sustainability into common core requirements and/or the vision statement of the higher education institution.

A third strand of research focuses more on the *stages and dynamics* of curriculum change. Lattuca and Stark (2009) distinguish among the three stages of initiation, screening, and adoption, whereas Krizek et al. (2012) suggest four phases for successful implementation that range from basic and ad hoc sustainability activities to inter- and transdisciplinary collaboration among many stakeholders. This temporal perspective also incorporates the concepts of the history and traditions of HEIs as additional influencing factors in ESD implementation (Hoover and Harder 2015; Eckel et al. 1999) since certain traditions can lead to the preservation of a certain profile, thereby preventing further innovation or the incorporation of new disciplines.

Impetus of change is a fourth aspect of ESD implementation addressed by scholars. Lattuca and Stark (2009) distinguish between internal and external impetus, whereas Fumasoli and Lepori (2011) differentiate between motivation for curriculum change that is either normative or goal-oriented. Other authors further emphasize the importance of intrinsic motivation and consider underlying assumptions and a reflection on these assumptions to achieve full

implementation of sustainability curricula (Hoover and Harder 2015; Eckel et al. 1999; Barth and Michelsen 2013).

Finally, a dominant strand of research deals with identifying specific *drivers and barriers* that influence the sustainability curriculum implementation process. This research includes literature reviews (Velazquez et al. 2005), logic models (Barth 2015), descriptive and analytical single-case studies (Cebrián 2017; Johnston 2013), small-N comparative case studies (Ferrer-Balas et al. 2008), and surveys based on a greater number of HEIs (Lozano and Barreiro-Gen 2019; Ávila et al. 2017). The list of drivers and barriers is extensive and includes various internal and external stakeholders with unique sources of motivation, differing perceptions of sustainability and change, various underlying assumptions about ESD, and different organizational tools (e.g., a strategic plan and participation mechanisms) as well as different institutional and educational cultures.

Based on the numerous case studies published thus far, all curriculum change processes in HEIs appear to be unique and involve an individual context and history that impede both drawing comparisons and the ability of HEIs to learn from one another. However, in reference to existing lists of what are perceived as common drivers and barriers and amidst theories on change processes, Corcoran et al. (2004) rightfully raise the question of whether patterns exist among similar processes of sustainability curriculum change. Furthermore, various authors have provided guidelines for successful change processes that assume that comparable planned change processes exist (Junyent and Geli de Ciurana 2008; Velazquez et al. 2006).

Little attention has thus far been given to the relationship between influencing factors and specific patterns of implementation of higher education for sustainable development. In a recent study, Weiss et al. (2021) analyzed 133 case studies and found significant relationships between specific drivers and barriers and the level of implementation. Ferrer-Balas et al. (2008) compared seven cases using a framework–level–actor approach but did not identify shared patterns across cases. Based on a study of eight German HEIs, Barth (2013) identified three patterns of the evolution of sustainability curriculum change: (a) student-led change from informal to formal learning, (b) sustainability as a concern in campus operations, and (c) sustainability as a unique selling point.

Nevertheless, more theory formation is needed by considering the *interaction of various drivers and barriers*, the interlinkages between the *different aforementioned aspects (type of implementation, level of depth, stages and dynamics, impetus of change, drivers and barriers)*, and the issue of *generalization*.

To close this research gap, we performed a meta-analysis of 131 international case studies and focused on the form, extent, and role of the interactions of the drivers of

and barriers to ESD in specific implementation patterns. In so doing, we linked the patterns to the level of change and the type of integration, and—to the extent that the primary data can provide insight—we identified the source of change by situating the factors within the process. Furthermore, we derived cross-cutting influences that distinguish patterns from one another, are similar across patterns, and vary within patterns. We thereby aimed facilitate a better understanding of the implementation processes that underlie ESD by deriving insights on the following questions:

- o How does sustainability curriculum change take place in HEIs?
- p What interrelating factors lead to what level of implementation?

Research design

With the goal of deriving more generalizable knowledge on the role both of the various drivers and barriers discussed in the literature and of specific implementation patterns, we compared 131 case studies via the case survey method. A cluster analysis was used to analyze the transformed data. The case survey method is a meta-analytical technique for systematically synthesizing and comparing various case studies through a defined coding scheme that transforms qualitative data into quantitative data. When applying the case survey method, we used the steps suggested by Newig and Fritsch (2009) as a guide. These steps are outlined in Fig. 1.

A case was defined as a sustainability curriculum implementation process in one higher education institution. Case material was identified through a systematic review of peer-reviewed journal articles and book chapters (for more details, see Weiss and Barth 2019). Additional material was taken from the respective websites of the HEIs. Of the 230 identified cases, we selected 133 case studies based on the level of detail used in describing their sustainability curriculum implementation processes (for additional details, see Weiss and Barth 2020b). Two cases had to be excluded from the cluster analysis due to insufficient data, thereby resulting in 131 remaining cases (a full list is presented in Appendix Table 1). To transform the qualitative information into quantitative data, we developed an analytical scheme with 111 variables that included detailed operationalization (Weiss and Barth 2020c). Variables were predominantly classified as (a) barrier (lack of/weak), (b) medium (described, but with unclear/differing impact), (c) driver (high/strong), (d) other (if no category matched the description), or (e) not described (missing information). The implementation level (depth) was measured via Sterling and Thomas's (2006) classification by using the categories of denial, “bolt-on,”

Case survey method

1. Develop research questions.
2. Decide on the methodology.
3. Define case selection criteria.
4. Collect case sample universe.
5. Design initial coding scheme.
6. Pretest and create iterative revision of coding scheme.
7. Create final coding of cases through multiple raters.
8. Measure inter-rater reliability.
9. Resolve important – but not all – coding discrepancies.
10. Analyze biases statistically.
11. Analyze created case data set (statistical or otherwise).
12. Report the study.

Fig. 1 Applied steps of the case survey (adapted from Newig and Fritsch 2009)

“build-in,” and redesign (see Sect. [Introduction](#)). In the following section, we refer to more comprehensive sustainability curriculum implementation by describing the trend toward a redesign change. The cases were coded by 5 trained coders. The consistency of the ratings of two different coders was tested for 10% of cases that had an inter-rater agreement of 94% for these codings.

To test for specific patterns, we ran a cluster analysis in order to group all cases based on the relevant variables. We excluded variables that showed no or next to no variance. A list of the used variables can be found in [Appendix No. 1](#), with detailed descriptions in Weiss and Barth (2020c). We then performed an indicator species analysis to determine which variables are characteristic of and significant for a specific group. This method allowed us to identify groups that could be meaningfully explained by specific variables, and these groups were nested within larger groups to form a hierarchical structure. All analysis were done in R version 3.6.2.

Results

A short description of the case sample is shown in [Fig. 2](#) (for more details, see Weiss and Barth 2020a).

The cluster analysis reveals six specific patterns of sustainability curriculum implementation processes that can be found in HEIs (see [Fig. 3](#)). Each pattern takes into account the type of integration, the level of implementation, the dynamic and stages of the implementation process, the impetus of change, and further drivers and barriers. These factors are structured along the five categories of institutional environment, educational environment, internal stakeholders, external influences, and sustainability areas in the higher education institution.

The clusters of implementation processes can be linked to specific levels of implementation in line with Sterling and Thomas (2006) that range from a redesigning of the curriculum to bolt-on approaches. A detailed summary of the variables used to describe the clusters via commonalities and differences both between and within the patterns is provided in the electronic supplementary material (S1). However, since we describe the clusters as analytical constructs to shed light on specific change processes, the distinction is analytical, and the boundaries between the patterns are fluid.

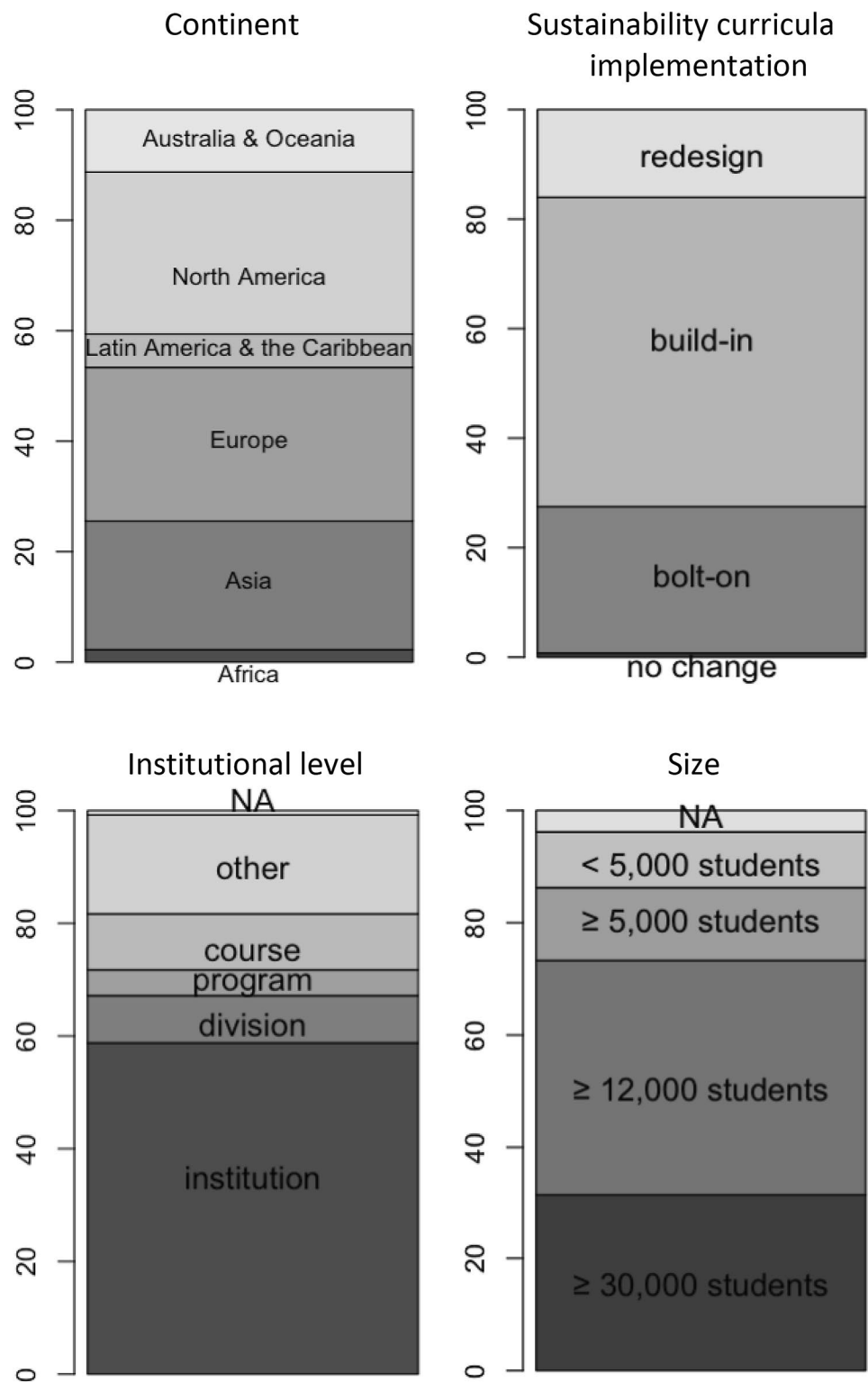
Furthermore, in [Fig. 4](#), a dendrogram of the six sustainability curriculum implementation patterns is used to indicate which main variables influence the specific separation of the clusters. The length of the vertical lines is proportional to the distance between the clusters. To arrive at six distinct clusters, the cases were separated successively into finer groupings that are characterized by the most significant variable in the newly emerged cluster, with an indicator value explaining the degree of internal similarity.

Cluster 1: collaborative paradigm change

The first cluster represents cases for which the entire institution’s curriculum implements sustainability following a redesign approach that is characterized by manifold relationships and connections. Key identifiers for this pattern are *fruitful collaboration and strong support of all internal and external stakeholders, a formal participation process, a broadly accepted guiding vision statement, and sustainability implementation across education, research, campus operations, and outreach* that results in an overall *paradigm change*. Other scholars refer to this type of integration as a “whole-institution approach,” in which sustainable development is institutionalized in all areas and at the core of the HEI (D’Andrea and Gosling 2005).

Sustainability champions in the higher education institution provide the impetus for implementing ESD. The implementation of ESD is further supported externally by a broad range of stakeholders, which leads to a sense of urgency through increased external pressure and to coalitions of various internal and external stakeholders. While early activities can be driven either top-down or bottom-up, leadership commitment at an early stage is also a common

Fig. 2 Sample description (N = 131 case studies; y-axis shows count in percent)



characteristic of this pattern. This top-management support enables a formal collaborative visioning process that defines ESD goals for the higher education institution by involving the campus community. This participation results in a formalized vision statement and strategy that is executed and

further monitored by a quality assessment system. To implement the strategy, the organizational structure is adapted accordingly. Dedicated resources—such as funding, faculty training, ongoing dialogue-focused communication, and collaboration—ensure a long-lasting change process.



Fig. 3 Six analytical patterns of sustainability curriculum implementation in HEIs that emerge from a case survey analysis of 131 international case studies based on a Ward cluster analysis

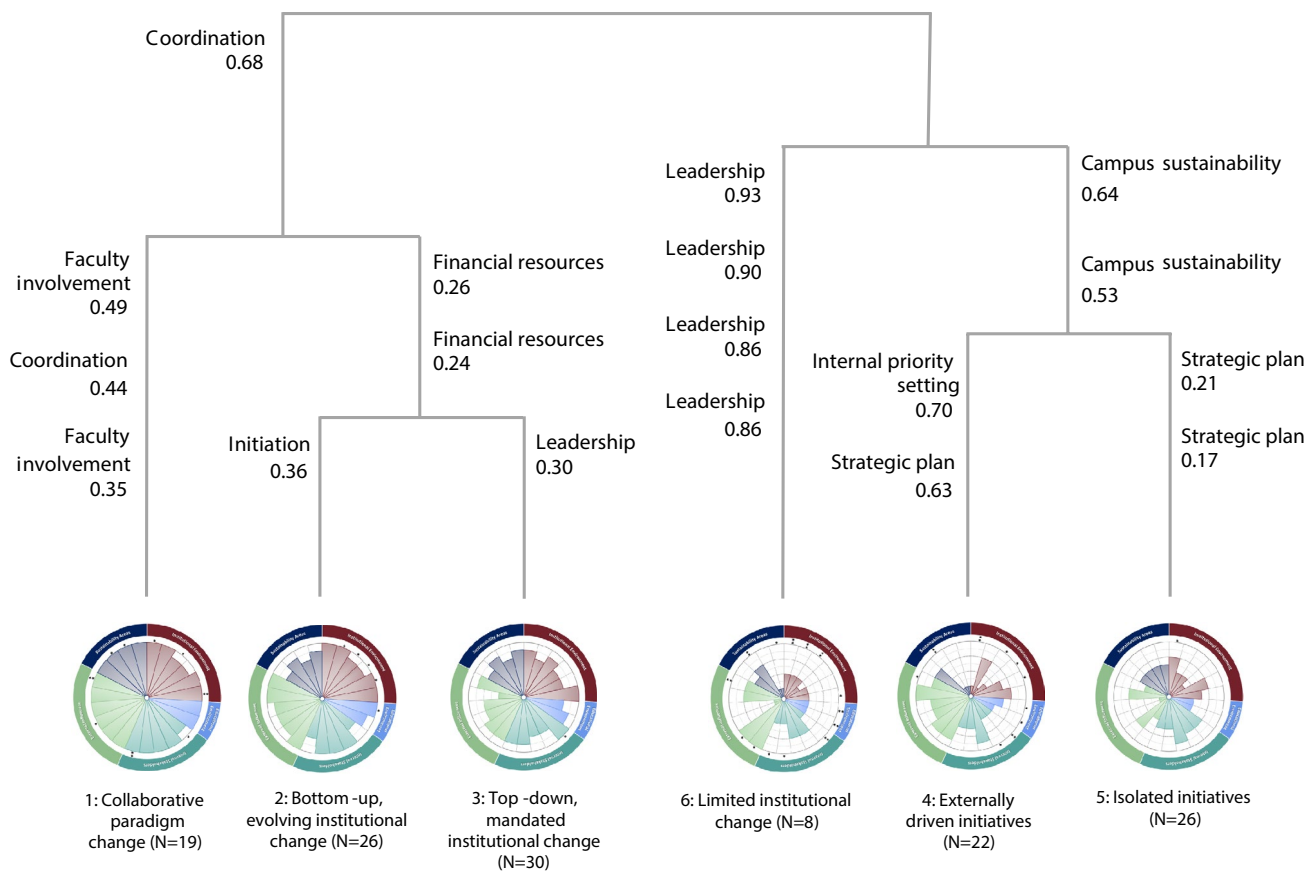


Fig. 4 Dendrogram of distinct change processes used in implementing sustainability curricula. Based on a Ward cluster analysis of 131 international case studies

In most cases, this type of implementation is led either by a distributed leadership model or by a cross-faculty steering group to ensure the buy-in of all disciplines and departments. Over time, synergies between research, education, and campus operations are explored and utilized. Formal faculty training, interdisciplinary spaces (e.g., a sustainability faculty and interdisciplinary centers), communities of practice, and faculty fellow programs are among the various measures used to sustain a redesign approach when implementing sustainability curricula.

Cluster 2: bottom-up, evolving institutional change

The second cluster includes cases with bottom-up, value-driven change that goes beyond the implementation level that was initially expected or planned, thereby resulting in a redesign level of sustainability curriculum implementation with occasional build-in tendencies. These cases are characterized by *bottom-up initiation* and high levels of internal *informal collaboration*, with *presidential leadership support joining in at a later stage* in the implementation

process, thereby leading to more formalized support and collaboration.

Students and/or faculty begin the process by asking for and incorporating the first ESD courses and programs within only a few departments. These initiatives often have their start in environmental projects, such as recycling initiatives.

To drive implementation forward and ensure a critical mass of supporters, an informal facilitation strategy characterized by knowledge exchange through informal communicative arenas (e.g., a communities-of-practice approach, digital exchange, and a learning platform) is undertaken with the aim of seeking solidarity among the campus community and of sharing resources to implement ESD. As presidential leadership support and dedicated financial resources are rather weak in this phase, more creative methods are used to allocate (mostly external) funding, such as sharing costs with the city or creating a sponsoring club. After the first phase, the initially rather weak presidential leadership support evolves into greater support through a change in the leadership team or increased awareness. As a result, the facilitation strategy transitions from a bottom-up initiative to a more leadership-supported, formalized strategy and facilitation.

Communication, support mechanisms (e.g., professional development), the occasional participation of internal and external stakeholders, and quality assurance mechanisms are formalized. In most cases, ESD is also laid out in the institution's vision statement. Over time, sustainability is established across education, research, campus operations, and outreach, with occasional synergies between areas.

Cluster 3: top-down, mandated institutional change

The third cluster includes cases that are mandated by presidential leadership, with missed opportunities to facilitate a deeper value-driven cultural change leading mostly to a build-in implementation. The cluster is characterized by *initiation and execution by presidential leadership* and by *a lower sense of faculty ownership*—that is, less motivation for and responsibility in the implementation of ESD.

Extrinsic motivation—such as governmental requirements, the need to restructure the higher education institution, or the desire for a competitive advantage—provides the impetus for change. As the change is planned from the top, a strategic plan is developed, a coordination unit is established, and some support mechanisms are offered. The university leadership only partially establishes ESD in the vision statements of the HEIs (i.e., in 50% of cases), and the focus often lies on the environmental dimension of sustainability. Formal participation of internal stakeholders (faculty, students) is only partly established, thereby leading to insufficient involvement of the campus community, a lack of effective communication, and the lack of a unified and guiding vision statement. This lack of participation often leads to faculty resistance to the implementation of ESD and to the lack of a sense of ownership since the faculty's opinions are not involved. To cope with the resistance of faculty members, some cases report that professional development opportunities or informal communication (e.g., over a cup of tea) help to alleviate resistance against the implementation of ESD. In other areas of the institution, environmental sustainability is implemented in research and campus operations as well as—to a lesser extent—in outreach activities, in which case, fewer synergies between the above-mentioned university areas and sustainability courses are created.

Cluster 4: externally driven initiatives

Cluster four includes cases with weak internal support, which is to a certain extent compensated by strong external support, thereby resulting in a bolt-on or build-in implementation level. This sustainability curriculum implementation pattern is characterized by *weak internal support and planning* and a *strong external driver*.

An external impetus supports the initial phase of the sustainability curriculum change since internal support is weak

at this time. The lack of internal support is also reflected in a lack of description of the many variables, such as a strategic plan, presidential leadership, collaboration, coordination, communication, incentives, and organizational structure. However, two different subgroups related to different processes for coping with the lack of internal support can be distinguished:

- 1) The first subgroup involves cases that implement ESD mostly at the program level with the support of (inter) national networks (i.e., research collaborations with other HEIs or teaching collaborations, such as a joint remote lecture program) or of Regional Centers of Expertise (RCE). Strong external collaboration and coordination play a key role here. Internally, sustainability champions drive the process. Further connections to other areas of the institution—such as campus operations—are poorly outlined in these cases. However, in 50% of cases, ESD is established in the current (2018/19) vision statement (data are available from the respective websites), which may indicate that external collaboration can lead to more comprehensive sustainability curriculum implementation.
- 2) The second subgroup involves cases in India that have achieved a mostly bolt-on implementation level. For these cases, the external impetus for implementing ESD comes from the government since environmental studies in India are mandated by the country's Supreme Court. Additional demand for ESD comes from industry as well as from public discourse. As environmental education (EE) is mandatory for every undergraduate student in India, the integration approach chosen by the HEIs is a mandatory course for all undergraduate students. To cope with weak internal support, weak interdisciplinary competence of the faculty in teaching EE or ESD, and contrasting perceptions of possible links between EE/ESD and the existing disciplines and courses, curriculum change is supported externally. An RCE facilitates the implementation of ESD, and an NGO develops the course and prepares the teaching materials. Moreover, the traditional examination system—which inhibits innovative teaching and learning approaches—and the lack of a sustainability vision statement act as barriers to implementing ESD.

Cluster 5: isolated initiatives

The fifth cluster consists of cases with initiatives that struggle to collaborate with one another and that are accompanied by weak priority setting, which leads to build-in or bolt-on implementation. The cluster is characterized by the involvement of *few stakeholders* and by *weak coordination*

and cross-faculty collaboration, thereby resulting in isolated initiatives.

The initiation of ESD occurs either top-down or bottom-up. The motivation for implementing ESD varies and can be value-driven at the one extreme or externally motivated via governmental support or international research projects at the other extreme. After initiating ESD efforts, the support provided by presidential leadership varies from medium to strong. An implementation strategy is developed for some cases in the cluster, albeit without concrete steps and with no or weak quality assessment. Broader stakeholder participation is rather weak, which leads to the lack of a unified vision statement. Moreover, the institutions are characterized by a competitive environment with competition between different stakeholders and university areas. A faculty's lack of interdisciplinary competence and collaborative ability—paired with the lack of an integrative framework in the coordination and support of the efforts—results in fragmented and isolated ESD implementation approaches that are steered by few sustainability champions. Externally, ESD awareness in the local community and industry is rather low. However, some external support comes from international research projects or partnerships with other HEIs as well as from governmental support.

Sustainability in other areas of the institution is rather low, with most activity taking place in outreach, followed by research, and with no activity in campus operations. External faculty training, student-led courses, and certificates represent integration approaches that may only be one-time offerings.

Cluster 6: limited institutional change

Cluster six consists of cases with bottom-up activities that struggle to establish their activities permanently due to many barriers and to a lack of support, thereby resulting in a bolt-on or build-in implementation level. The *number of described barriers*—that is, the *weak support of various stakeholder groups*, *unused momentum*, and the *inability to establish long-lasting internal cultural change*—is the key factor that characterizes this cluster.

The impetus behind ESD implementation originates from bottom-up, value-driven motivation. As sustainability champions struggle to gain further support, the process is characterized by many barriers. For instance, the lack of a strategic plan, weak leadership support, weak interdisciplinary competence of the faculty that teaches ESD, differing levels of ESD acceptance by students, the lack of any formal involvement of stakeholders, weak internal collaboration, weak professional development opportunities, a lack of incentives and resources, and weak implementation in other areas of the institution inhibit stronger ESD implementation.

Externally, the government acts as a driver of ESD by setting international and national guidelines.

Within this cluster, two different subgroups can be distinguished:

- 1) The first subgroup includes cases in Vietnam that achieve a bolt-on sustainability curriculum implementation level. In some cases, either environmental degradation, the National Action Plan for Sustainability, or UNESCO initiatives provide additional impetus to implement ESD. However, the potential lack of both a cultural understanding of ESD and traditional didactic approaches serves as a strong barrier to ESD implementation.
- 2) The second subgroup includes cases with long and diverse histories of ESD implementation that are characterized by many barriers. These cases often achieve a build-in approach driven by sustainability champions. Differing levels of leadership support, the lack of a detailed strategy, partly insufficient coordination, and poor communication act as strong barriers to ESD. Only one case in our study managed to achieve more comprehensive ESD implementation by gaining broader support through a change in top management and by formalizing ESD in the institution's vision statement.

Discussion

Using a meta-analytical technique to investigate 131 international HEIs, this study yielded generalizable results on specific patterns of sustainability curriculum implementation processes. Analyzing and comparing the six derived clusters sheds light on the role of specific variables that function either as a driver of or a barrier to ESD implementation, depending on the specific context. These clusters are instrumental in characterizing specific patterns as well as in fostering or inhibiting full implementation of sustainability curricula.

However, these insights are limited. First, the majority of the analyzed case samples represent sustainability curriculum implementation processes only from particular countries and continents and thus present an imbalanced global view (for a full list of cases, see Appendix Table 1). Second, comparing case studies as secondary data has various limitations, including the use of varying points of focus, perspectives, and methodologies in the publications. For example, one reviewer of this paper highlighted the fact that many HEIs exist in India that have implemented ESD programs and therefore tend to represent build-in- rather than bolt-on approaches. We, therefore, wish to emphasize that this meta-study only encompasses HEIs with published case studies containing qualitative data and information on the studied

time periods. Such a meta-study has limitations when it comes to reflecting today's reality, but it offers the potential to understand the connections between influences and their impact at the time of the respective publication dates. Follow-up studies with extended data collection via surveys or interviews will provide complementary data points.

Third, as many case studies are self-reported, a bias toward success stories exists that excludes barriers, failures, and underlying influences. Fourth, when computing statistical analyses, we considered missing information to be irrelevant, though this may not be the case, for example, due to differing publication strategies of the various HEIs or to a lack of research. Furthermore, as gaps in data availability exist, tracking a complex process over several decades proved challenging. For some cases, we could only gain a general impression of the sustainability curriculum implementation process, and exactly how the specific processes evolved and prospered often remained unclear. Finally, Clusters 4 and 6 included a comparative case study that constituted a large share of the cases in these clusters. For these cases, a broader database would be desirable to confirm the existence of the subgroups of the implementation processes identified within these clusters.

Nevertheless, the data reveal an overall trend toward more comprehensive sustainability curriculum implementation based on the number of cases.

Additional studies have indicated that this more comprehensive implementation can be more easily achieved in smaller HEIs (Ferrer-Balas et al. 2008), though this finding cannot be confirmed with our data.

The question as to whether different patterns arise in different contexts, continents, and countries is also valid. Local contexts can present special cases if certain traditions are highly dominant, if the investigated regions have suffered from environmental catastrophes, or if national governmental guidelines provide certain boundaries or support. No significant differences were found across continents or countries in terms of either specific patterns or the level of implementation. However, our data did reveal that North American cases are dominant in Cluster 3 (top-down, evolving institutional change).

The comparison with Barth's (2013) previously identified patterns does not match with our patterns of sustainability implementation processes. However, various common features can be found. The pattern (a) of "student-led change from informal to formal learning" (Barth 2013) overlaps significantly with Cluster 2 ("bottom-up, evolving institutional change"); however, we found that the implementation of ESD is steered not only by students, but also by other active sustainability champions. Furthermore, our data do not identify the other two patterns described by Barth (2013) (i.e., (b) "sustainability as a concern in campus operation" and (c) "sustainability as a unique selling point") as single

patterns and instead identify them as a source of motivation or impetus across various patterns.

When comparing the patterns, it becomes clear that they often share a certain set of variables (although these variables differ in form and extent), as is further reflected in the achieved level of sustainability curriculum implementation. These variables influence the implementation of sustainability curricula in two distinct phases, which are clearly visible in the analysis and are discussed in greater detail below.

Phase 1: Initiation of sustainability curriculum implementation

All stakeholders can initiate sustainability curriculum change: throughout the clusters, various internal and external stakeholders can be found to initiate a full implementation process, including students, faculty, leadership, and external stakeholders (e.g., international researchers). Internal stakeholders are more powerful than external stakeholders in enabling change within higher education institutions. Actions from sustainability champions—such as faculty and students—can scale up if they are taken seriously and if they are not considered to represent competition for ESD initiatives that are initiated by presidential leadership. However, if internal champions lack broader internal support for driving the implementation forward, external support that compensates for the lack of internal support is beneficial. This support and knowledge exchange can take the form of partnerships with networks, research projects, or Regional Centers of Expertise. Furthermore, an external impetus can be most helpful in pushing for stronger internal recognition of the need not only to support the change, but also to begin the process of ESD implementation. For instance, local authorities may exert pressure at the leadership level, new governmental guidelines may be established, or the level of local awareness may increase through environmental catastrophes, such as earthquakes. We found that governmental support is conducive to ESD implementation across all patterns, but greater influence—especially internal support from the faculty, communication, and coordination—is needed for more comprehensive implementation.

These insights support findings from previous studies. For example, Hoover and Harder (2015) have found that curriculum change is driven by many different stakeholders, occurs on different levels (top, middle, grassroots), and is influenced by the perception of who has the power to affect change. Moreover, Eckel and Kezar (2003) have further highlighted the notion that curriculum change is an open-systems process in which outsiders, in particular, play an important role in creating new ideas and facilitating change. Furthermore, support of senior leadership has been found to be a critical factor in more comprehensive sustainability curriculum implementation (De La Harpe and Radloff 2003).

The implementation of sustainability curricula can begin with individual initiatives in education, campus operations, research, or outreach activities: we found that both across and within patterns, the impetus for implementing sustainability in education often has its starting point in other areas of the institution. For instance, a higher education institution with a focus on a sustainable campus management system often expands the topic of sustainability to the educational area at some point after students have expressed interest in learning more about campus recycling initiatives via courses and programs. Another possibility for implementing sustainability curricula lies in transferring it from the area of research to that of education, which may begin in a collaborative project with external and/or inter- or transdisciplinary partners. Other studies have also found that it is conducive to involve all areas of a higher education institution in implementing sustainability topics in order to achieve more comprehensive sustainability curriculum implementation (Velazquez et al. 2005).

Phase 2: achieving and sustaining more comprehensive ESD implementation

Communication is key to obtaining a critical mass of supporters: we found that across patterns, the form and extent of communication- and participation initiatives differentiate the patterns of ESD implementation. More comprehensive implementation is always accompanied by a communication- and participation strategy to create a sense of ownership, formalize the change in a unified guiding vision statement, and make the impact last. It does not matter which stakeholder group begins the communication process; however, at some point, a formal, broad-based communication process that is supported by the institution's leadership is more powerful as it can evolve into a formal participation- and decision-making process. The more seriously that communication is seen as a two-way process with a focus on mutual feedback and participation, the higher the achieved level of sustainability curriculum implementation will be as this implementation helps to create an understanding of sustainability and a desire for its integration. Useful tools in this process can include starting an awareness-raising campaign (e.g., a sustainability inventory that shows sustainability initiatives that have already been implemented), creating communicative arenas, running a web portal (public wiki) that provides feedback on a strategic plan, and fostering a collaborative visioning process. Interdisciplinary spaces enable more comprehensive sustainability curriculum implementation but must be supported by leadership. Where such formal communication measures are not available, informal opportunities for champions to exchange knowledge and motivate one another can serve as partial compensation.

These findings are in line with previous research, which has highlighted the role of communication in change processes. Eckel et al. (1999) have stressed the importance of the engagement of the campus community, and De La Harpe and Thomas (2009) have synthesized research on the role of communication and concluded that a unified vision statement and a shared understanding of ESD are relevant in creating a sense of ownership. Furthermore, fostering open communication and a transparent decision-making process is equally important for building trust among the campus community. Finally, a paradigm change is not merely a behavioral change, but rather a change of mental models (Eckel and Kezar 2003), and both knowledge exchange and communication form an essential part of learning. Hoover and Harder (2015) have pointed out that dialogue and reflexive practices are key to recognizing tensions and steering change process.

Collaboration within and among stakeholder groups is key to more comprehensive implementation and to balancing a lack of support or resources: collaboration has been identified as a main driver of more comprehensive implementation. Strong internal collaboration and knowledge sharing can increase solidarity between all stakeholders. A competitive environmental setting hinders further ESD implementation, because the focus here lies on goals that drive academics' careers. In these settings, knowledge is often not shared, and less collaboration generally occurs. Sometimes, competitive programs are even established.

External collaboration can balance out the lack of broad-based internal support of ESD implementation to a certain extent by supporting individual internal sustainability champions. For instance, HEIs with weak local support often create partnerships with (inter)national HEIs, networks, or Regional Centers of Expertise through (collaborative) research projects. The data point to the fact that such external collaboration can serve as an important starting point for more comprehensive ESD implementation since 50% of these cases implement ESD in their current (2018/19) vision statement.

Collaboration can be identified not only across stakeholder groups but also across university areas (research, campus operations, outreach). The more that internal and external stakeholder groups are active (*participation, collaboration, and support*) in the process and the more that different areas of the higher education institutions are involved, the more comprehensive the implementation is (paradigm change).

The important role of collaboration and cooperation as opposed to competition and the involvement of a wide range of stakeholders have also been emphasized by further studies (Fumasoli and Lepori 2011; Eckel et al. 1999). In a comparison of 7 HEIs, Ferrer-Balas et al. (2008) conclude that collaboration in the form of a network of experts—or stakeholders—who connect a higher education institution

with society serves as a driving factor in the implementation of ESD. Moreover, Hoover and Harder (2015) have revealed in a meta-ethnography of 13 studies that collaboration helps to break down internal boundaries since meeting new people leads to learning and reflecting on one's own assumptions and values.

Coordination conserves resources, helps to create synergies, and enables progress to be tracked. Another key variable in achieving more comprehensive sustainability curriculum implementation is the presence of any type of coordination, such as shared responsibilities between faculties or the designation of a position or committee to coordinate ESD implementation across the entire institution.

A formalized strategic plan with clearly defined steps over a longer time period helps to clarify the desired vision statement, which then fosters stronger and ongoing support from all stakeholders. Coordinated quality assurance mechanisms are one tool that can be used to assess the current sustainability curriculum change and to plan further steps for more comprehensive implementation. Moreover, coordination supported by the leadership of the institution should ensure that initiatives within one and the same institution are not repeated and do not compete for the same resources. Across cases, we found that strong collaboration can balance out a lack of financial, human-, or time resources by providing creative and efficient knowledge exchange and that this collaboration can lead internal stakeholders to seek creative financial solutions. Furthermore, the coordination and connection of many ESD initiatives creates synergies and conditions that enable sustainability curricula to be redesigned, which would not have been possible via isolated initiatives alone. For instance, at the educational level, more innovative learning approaches are possible, such as living labs, partnerships with the community, and real-life projects.

The role of coordination has also been identified in other studies on curriculum change. De La Harpe and Radloff (2003) have emphasized the importance of assigning responsibilities to tasks and of monitoring the progress of ESD institutionalization. Moreover, Ferrer-Balas et al. (2008) have highlighted the importance of coordination bodies as a main driver of ESD implementation, and Fumasoli and Lepori (2011) have stressed the importance of the dynamic relationship between formal and informal processes that are used—inter-alia—to gain acceptance and support for ESD from the campus community, to coordinate initiatives, and to control curriculum change. Additionally, Hoover and Harder (2015) have pointed out that “structures need to be multiple, and developed and managed in ways that allow flexibility, where they support (not govern) processes of change and value different types of leadership” (Hoover and Harder 2015, p.12). Furthermore, processes of sustainability curriculum change should be conceived as a form of double-loop learning within an organization, and the core of the

change process should consist of reflecting existing values and questioning existing programs and structures (Hoover and Harder 2015).

Considering the different patterns and characteristics of the key influences, it remains unclear whether HEIs can transition between different patterns and how they can progress toward a pattern with more comprehensive ESD implementation. It is important to note that despite generalizable influencing factors, implementation processes are bound to individual contexts. Therefore, the patterns can be seen as different processes that are used to achieve the institutionalization of sustainability curricula rather than as different stages through which the HEI must transition. Nevertheless, important interlinkages exist between the key influences and between how handling these influences leads to different implementation stages. Indeed, HEIs can transition between different patterns, but they do not have to. For example, a well-steered change process may transition very quickly to a redesign stage without passing through any other stage or pattern. Moreover, in order to achieve more comprehensive implementation of ESD, an HEI can reflect on its current pattern. By examining the key factors and comparing how they operate in another pattern, next strategy steps for transitioning to another pattern can be derived, such as requiring stronger formal participation of internal stakeholders and developing a common vision.

Conclusions

Our analysis of 131 case studies identified six distinct patterns of implementation processes of sustainability curricula, which range from (1) collaborative paradigm change (redesign) to (6) limited institutional change (bolt-on change). However, certain patterns seem to be more conducive to more comprehensive implementation, especially in the build-in stage, in which several methods of implementation exist, including a bottom-up and a top-down process of achieving full implementation. By comparing these sustainability curriculum implementation processes, we identified five key influences in the implementation of sustainability curricula in HEIs:

- 1) The impetus for change during the initiation of ESD implementation can have manifold sources, including internal or external stakeholders with varying amounts of decision-making power (faculty, students, presidential leadership, outsiders) and various areas of the higher education institution (research, campus, outreach, education).
- 2) Communication—understood as information, mutual feedback, participation, and reflection on one's own assumptions and values—is key to obtaining a criti-

- cal mass of supporters to sustain ESD implementation. Informal communication can compensate for a lack of formal communication and professional development.
- 3) Creating a sense of ownership through a unified guiding vision statement and strategy via the broad participation of internal and external stakeholders (that take various perspectives into account and develop a shared and comprehensive understanding of ESD and the desired HEI's vision statement) is conducive to more comprehensive implementation.
 - 4) Seeking collaboration and coalitions with many internal/external stakeholders as well as with university areas (research campus, outreach)—even with areas with different sources of motivation—is critical to sharing knowledge and resources, to enabling broad-based change, and to creating synergies with mutual benefits. External coalitions can compensate (to a certain extent) for a lack of internal support.
 - 5) Coordinating various initiatives conserves resources while connecting individual ESD efforts and creating synergies among them. More comprehensive implementation can be enabled by reflecting on the usefulness of organizational structures as well as by modifying them and monitoring these processes.

As qualitative data are the main source used in this study to further investigate patterns of ESD implementation, future research should focus on the quality of single- or comparative case studies and take into account the manifold variables that influence ESD implementation in HEIs. To do this, it is critical to determine (a) which factors do and *do not* influence the implementation of ESD. Relationships between factors are often particularly underrepresented in current studies, and future studies should make coping strategies that are used to react to barriers more explicit and accessible in order to enable shared experiences between HEIs. Similarly, case studies should reflect more thoroughly on specific contexts in terms of traditions, organizational cultures, countries, etc. For example, using the case studies, it was difficult to determine when and in what ways global ESD initiatives—such as the UN Decade—have influenced the implementation process of sustainability curricula. References in the case studies were mostly very general, although the publication dates of many case studies coincided with the UN Decade. Nonetheless, further research could focus on tracking and understanding such influences more precisely. Moreover, greater focus should be placed on collecting data from and analyzing the many perspectives of various stakeholders and their specific underlying assumptions. Additionally, future studies should more explicitly delineate (b) the different phases of the process of ESD implementation (e.g., to determine when a specific influence is important). Finally, future

case studies should more accurately explain (c) the achieved change and the level of ESD implementation.

Furthermore, continuing to embed case study research on ESD implementation in curriculum change theories should help foster an understanding of the specific patterns of sustainability curriculum change.

Other future research could investigate how collaboration and double-loop organizational learning can be fostered in a higher education institution in order to bring about sustainability curriculum change, even if there is a lack of other resources (e.g., incentives).

To further test the patterns of this meta-study and fill data gaps, follow-up studies must collect additional data types. For example, in-depth studies that collect detailed data on some HEIs through interview data or that extract ESD initiatives from other databases (e.g., International Associations of Universities: <http://iau-hesd.net/profils-des-universites>) could contribute further data on the implementation process and the current status of each case of implementation. In this context, the usability of data collected during sustainability assessment, reporting, and monitoring at HEIs should also be further explored.

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References

- Acevedo-Osorio Á, Hofmann-Souki S, Cruz Morales J (2020) Holistic competence orientation in sustainability-related study programmes: lessons from implementing transdisciplinary student team research in Colombia, China Mexico and Nicaragua. *Sustain Sci* 15(1):233–246
- Avery H, Nordén B (2017) Working with the divides. *Int J of Sus in Higher Ed* 18(5):666–680
- Ávila LV, Leal Filho W, Brandli L, Macgregor CJ, Molthan-Hill P, Özuyar PG, Moreira RM (2017) Barriers to innovation and sustainability at universities around the world. *J Clean Prod* 164:1268–1278
- Barth M (2013) Many roads lead to sustainability. A process-oriented analysis of change in higher education. *Int J of Sus in Higher Ed* 14(2):160–175
- Barth M (2015) Implementing sustainability in higher education. Learning in an age of transformation. Routledge studies in sustainable development, Routledge, London
- Barth M, Michelsen G (2013) Learning for change. An educational contribution to sustainability science. *Sustain Sci* 8(1):103–119
- Cebrián G (2017) A collaborative action research project towards embedding ESD within the higher education curriculum. *Int J of Sus in Higher Ed* 18(6):857–876
- Corcoran PB, Walker KE, Wals AEJ (2004) Case studies, make-your-case studies, and case stories. A critique of case-study methodology in sustainability in higher education. *Environ Educ Res* 10(1):7–21
- Cuban L (1999) How scholars trumped teachers: change without reform in university curriculum, teaching, and research, 1890–1990. Teachers College Press
- D'Andrea V, Gosling D (2005) Improving teaching and learning in higher education: a whole institution approach. McGraw-Hill Education, UK
- De La Harpe B, Radloff A (2003) The challenges of integrating generic skills at two Australian universities. *Staff Educ Dev Int [spec Edit]* 7(3):235–244
- De La Harpe B, Thomas I (2009) Curriculum change in universities. Conditions that facilitate education for sustainable development. *J Educ Sustain Dev* 3(1):75–85
- Eckel PD, Green M, Hill B, Mallon W (1999) Taking charge of change: a primer for colleges and universities. American Council on Education, Washington, DC
- Eckel PD, Kezar A (2003) Key strategies for making new institutional sense: ingredients to higher education transformation. *High Educ Policy* 16(1):39–53
- Ferrer-Balas AJ, Banas S, Davidson CI, Hoshikoshi A, Mishra A, Motodoa Y, Onga M, Ostwald M (2008) An international comparative analysis of sustainability transformation across seven universities. *Int J of Sus in Higher Ed* 9(3):295–316
- Fullan M (2007) The new meaning of educational change, 4th edn. Routledge, London
- Fumasoli T, Lepori B (2011) Patterns of strategies in Swiss higher education institutions. *High Educ* 61(2):157–178
- Gaugh S, Scott W (2001) Curriculum development and sustainable development: practices, institutions and literacies. *Educ Philos Theory* 33(2):137–152
- Hoover E, Harder MK (2015) What lies beneath the surface? The hidden complexities of organizational change for sustainability in higher education. *J Clean Prod* 106:175–188
- Johnston LF (ed) (2013) Higher education for sustainability: cases, challenges, and opportunities from across the curriculum. Routledge, New York
- Junyent M, Geli de Ciurana, AM (2008) Education for sustainability in university studies. A model for reorienting the curriculum. *Br Educ Res J* 34(6):763–782
- Kapitulčinová D, AtKisson A, Perdue J, Will M (2018) Towards integrated sustainability in higher education – Mapping the use of the Accelerator toolset in all dimensions of university practice. *J Clean Prod* 172:4367–4382
- Kotter JP (1996) Leading change. Harvard Business School Press, Boston, Mass
- Krizek KJ, Newport D, White J, Townsend AR (2012) Higher education's sustainability imperative: how to practically respond? *Int J of Sus in Higher Ed* 13(1):19–33
- Lambrechts W, Mulà I, Ceulemans K, Molderez I, Gaeremynck V (2013) The integration of competences for sustainable development in higher education: an analysis of bachelor programs in management. *J Clean Prod* 48:65–73
- Lattuca LR, Stark JS (2009) Shaping the college curriculum. Academic plans in context, 2nd edn. John Wiley & Sons
- Lidgren A, Rodhe H, Huisingh D (2006) A systemic approach to incorporate sustainability into university courses and curricula. *J Clean Prod* 14(9–11):797–809
- Lozano R, Barreiro-Gen M (2019) Analysing the factors affecting the incorporation of sustainable development into European higher education institutions' curricula. *Sustain Dev* 4(2):126
- Meadows D (1999) Leverage points: places to intervene in a system. The Sustainability Institute, Hartland
- Newig J, Fritsch O (2009) The case survey method and applications in political science. Paper presented at the APSA 2009 meeting, 3–6 September 2009, Toronto. Panel on “Case study meta-analysis: methodological challenges and applications in the political sciences”
- Orr DW (2004) Earth in mind: on education, environment, and the human prospect. Island Press
- Pardellas Santiago M, Meira Cartea P, Iglesias da Cunha L (2017) Transition communities and the glass ceiling of environmental sustainability policies at three universities. *Int J of Sus in Higher Ed* 18(4):576–593
- Roy SG, de Souza SP, McGreavy B, Druschke CG, Hart DD, Gardner K (2020) Evaluating core competencies and learning outcomes for training the next generation of sustainability researchers. *Sustain Sci* 15(2):619–631
- Sachs JD, Schmidt-Traub G, Mazzucato M, Messner D, Nakicenovic N, Rockström J (2019) Six transformations to achieve the sustainable development goals. *Nat Sustain* 2(9):805–814
- Sipos Y, Battisti B, Grimm K (2008) Achieving transformative sustainability learning: engaging head, hands and heart. *Int J of Sus in Higher Ed* 9(1):68–86
- Stephens JC, Hernandez ME, Román M, Graham AC, Scholz RW (2008) Higher education as a change agent for sustainability in different cultures and contexts. *Int J of Sus in Higher Ed* 9(3):317–338
- Sterling S, Thomas I (2006) Education for sustainability: the role of capabilities in guiding university curricula. *Int J Innov Sustain Dev* 1(4):349–370
- United Nations (UN) (2015) Transforming our world: The 2030 agenda for sustainable development: resolution 70/1
- United Nations Educational, Scientific and Cultural Organization (UNESCO) (2016) Information folder: UNESCO global action programme on education for sustainable development. <https://unesdoc.unesco.org/ark:/48223/pf0000246270?posInSet=1&queryId=41054455-4753-4863-a5a8-c72533099f8e>
- United Nations Educational, Scientific and Cultural Organization (UNESCO) (2020) Education for sustainable development: a roadmap (#ESDfor2030)

- Velazquez L, Munguia N, Sanchez M (2005) Deterring sustainability in higher education institutions. *Int J of Sus in Higher Ed* 6(4):383–391
- Velazquez L, Munguia N, Platt A, Taddei J (2006) Sustainable university: what can be the matter? *J Clean Prod* 14(9–11):810–819
- Verhulst E, Lambrechts W (2015) Fostering the incorporation of sustainable development in higher education. Lessons learned from a change management perspective. *J Clean Prod* 106:189–204
- Weiss M, Barth M (2019) Global research landscape of sustainability curricula implementation in higher education. *Int J of Sus in High Ed* 20(4):570–589
- Weiss M, Barth M (2020a) Comparative analysis of sustainability curricula implementation processes in higher education institutions: a descriptive statistical report on the EFCA analytical scheme on sustainability curricula implementation processes in higher education institutions. Leuphana University Lüneburg. <https://bit.ly/EFCA-DescriptiveReportOnAnalyticalScheme>
- Weiss M, Barth M (2020b) Comparative analysis of sustainability curricula implementation processes in higher education institutions: a list of case studies that went into the analysis ($N = 230$). <https://bit.ly/EFCA-CaseUniverse>
- Weiss M, Barth M (2020c) Comparative analysis of sustainability curricula implementation processes in higher education institutions: a variable based analytical scheme. Working papers in higher education for sustainable development. Leuphana University Lüneburg. Center for global sustainability and cultural transformation 1 (ISSN (online) 2700-6735)
- Weiss M, Barth M, Wiek A, von Wehrden H (2021) Drivers and barriers of implementing sustainability curricula in higher education—assumptions and evidence. *High Educ Stud*. <https://doi.org/10.5539/hes.v11n2p42>
- Wiek A, Withycombe L, Redman CL (2011) Key competencies in sustainability. A reference framework for academic program development. *Sustain Sci* 6(2):203–218
- Yarime M, Trencher G, Mino T, Scholz RW, Olsson L, Ness B, Frantzeskaki N, Rotmans J (2012) Establishing sustainability science in higher education institutions. Towards an integration of academic development, institutionalization, and stakeholder collaborations. *Sustain Sci* 7(S1):101–113

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