How to Embed Sustainability in the Core of Higher Education Institutions

Drivers of, Barriers to, & Patterns behind the Implementation Processes of Sustainability Curricula

– Insights from a Quantitative Meta-Study with Data from around the Globe –

Academic dissertation

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Thesis submitted by

Marie Weiß

Born 9 February 1988 in Lübeck, Germany

LEUPHANA UNIVERSITÄT LÜNEBURG

CGSC ASU Center for Global Sustainability and Cultural Transformation

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ABSTRACT

This dissertation, entitled "How to Embed Sustainability in the Core of Higher Education Institutions: Drivers of, Barriers to, & Patterns behind the Implementation Processes of Sustainability Curricula – Insights from a Quantitative Meta-Study with Data from around the Globe," addresses the question of how sustainability curricula[1] can be implemented and established in higher education institutions[2]. This research question is based on the assumption that sustainable development requires new ways of thinking and acting in the world. Accordingly, universities – as hubs for knowledge generation, innovation, and education – provide a central leverage point for sustainably developing society at large. Therefore, the institutionalization of sustainability curricula is not only socially demanded, but also stipulated in numerous political statements from the international community (e.g., those of the UN and UNESCO) and operationalized via Sustainable Development Goal No. 4: "Quality Education".

Previous findings on *how* such implementation can be successful and what factors support or inhibit the process have come primarily through case studies of individual higher education institutions. These studies provide important insights but have been largely descriptive rather than analytical and leave open questions about the generalizability of their findings – for example, the extent to which other universities can be guided by the experiences of the respective higher education institutions.

The present dissertation addresses this research gap. Through a meta-study (i.e., an analytical comparison of existing case studies), generalizable findings on the implementation processes of sustainability curricula are explored. In the first step, a case universe was collected in order to provide a database for deeper analyses. In two further analysis steps that built on the case universe from Step 1, certain factors that promote or inhibit the implementation of sustainability curricula (Step 2) and specific implementation patterns (Step 3) were examined. The following paragraphs provide greater details and an overview of the respective findings.

In the first step, a database of peer-reviewed English-language case studies from around the globe that report on such processes was created. A total of 230 case studies were identified, 133 of which focus on the implementation processes of sustainability curricula.[3] A bibliometric analysis of the 230 case studies revealed that this field of research is growing, although the discourse is primarily dominated by authors from North America, Europe, Oceania, and Asia, with South America and Africa being underrepresented. In addition, a citation analysis demonstrated that some universities incorporate findings from other countries whereas other universities act in isolation. This observation

[1] Sustainability curricula include courses, programs, and certificates from all fields of study that deal in some form with sustainability topics. For a more-detailed discussion of what education for sustainable development (ESD) entails, see Section 3.1.

[2] Higher education institutions (HEIs) include universities, universities of applied sciences, and other institutions that offer at least a bachelor's degree.

[3] A detailed explanation of the case sample and subsamples can be found in Section 4.3.

leaves open the question of the extent to which universities learn from one another in order to advance the implementation of sustainability curricula.

In the second step of the analysis, the qualitative data of the collected case studies (sample of 133 case studies) were compared using the case survey method, which is a specific type of a meta-analysis. The focus of the comparison lay on the drivers of and barriers to the processes of sustainability curriculum implementation at higher education institutions. Driving- and inhibiting factors have been thoroughly examined theoretically in the discourse on education for sustainable development (ESD), especially those pertaining to higher education institutions. However, no large body of data has yet been created to empirically test these hypotheses. The present meta-study found that the following factors lead to the deep-rooted and comprehensive establishment of sustainability curricula: strong leadership support; the establishment of sustainability curricula in the areas of education, research, campus operations, and outreach activities; formal participation of internal (including students) and external stakeholders; and engagement by sustainability champions (change agents), who are often the first to implement sustainability curricula and can face strong resistance. Other enabling factors include strategic planning, coordination, communication, having a vision, external political influence, the presence of a window of opportunity (e.g., an environmental disaster, a change in presidency), and the availability of interdisciplinary meeting spaces. On the other hand, the strongest cited barriers to the implantation of sustainability curricula were found to be the lack of interdisciplinary meeting spaces, the lack of a vision, the lack of incentives, the lack of resources, an overly full curriculum, and an unsupportive / overly bureaucratic organizational structure.

The third step of the analysis also built on data from the 133 case studies and explored whether certain types or patterns of implementation processes occur. Through the analysis, six implementation patterns were identified that share similar driving- and inhibiting factors. The respective interplay between factors leads to various degrees of sustainability curriculum implementation in terms of how deeply rooted and comprehensive this implementation is. As discussed in greater detail below, in descending order of the level of achieved deep-rooted change, these patterns are (1) a collaborative paradigm shift, (2) bottom-up institutional change, (3) top-down institutional change, (4) the presence of many barriers that hinder institutional change, (5) externally driven initiatives, and (6) initiatives that are scattered due to a lack of coordination. Across all patterns, two phases could be identified: First, the impetus to implement ESD may be initiated not only by internal actors, but also by external ones. This initiation can take hold from the "bottom-up" (i.e., by students or faculty), from the "top-down" (i.e., at the presidential level), or in both directions simultaneously. The following key factors appear to be important in driving the initial implementation forward: a culture of open communication between all stakeholders in which feedback and reflection are welcome and even actively solicited, the development of a shared understanding and vision that further create a sense of ownership and long-term success, a high level of collaboration among all stakeholders, and existing initiatives that lead to knowledge sharing and other resources. In this regard, informal collaboration and cooperation can partially compensate for a lack of presidential-level support and/or

a formal communication structure. Furthermore, developing a strategy with individual steps and shared responsibility leads to more-successful implementation of ESD at higher education institutions.

The presented findings add a complementary empirical perspective to the discourse on the establishment of ESD at higher education institutions. First, the case studies that specifically address the implementation processes of sustainability curricula are reviewed and analyzed here for the first time as part of a research landscape. This research landscape reveals where research on such implementation processes has been or is being conducted. On this basis, both researchers and funders can reflect on the status quo and plan further research- or funding endeavors. Second, this dissertation offers the opportunity to compare a multitude of individual case studies and thus to develop new and generalizable insights into the implementation of sustainability curricula. The empirical analysis uses 133 case studies to identify key factors that promote or inhibit the implementation of sustainability curricula and to add a complementary perspective to the discourse, which has thus far been dominated by theoretical considerations and individual case studies. The analysis thereby offers a new perspective on generalizable influencing factors that appear to be important across different contexts. Thus far, specific patterns of implementation processes have been infrequently studied, and with few datasets. This dissertation analyzes the complex interplay between over 100 variables and provides one of the first research attempts at better understanding the processes that lead to the deep-rooted and comprehensive implementation of sustainability curricula. Internal and external practitioners of higher education institutions can find examples and evidence that can be useful in planning the next steps of their sustainability curriculum implementation.

In the future, higher education institutions will play an even greater role in the journey toward sustainable development. This dissertation offers generalizable empirical findings on how universities can succeed in recognizing their own responsibility to that end and in realizing this transformation through the implementation of ESD.

ZUSAMMENFASSUNG

Diese Dissertation "How to Embed Sustainability in the Core of Higher Education Institutions: Drivers of, Barriers to, & Patterns behind the Implementation Processes of Sustainability Curricula – Insights from a Quantitative Meta-Study with Data from around the Globe" geht der Frage nach, wie nachhaltigkeitsbezogene Curricula[4] an Hochschulen[5] implementiert und etabliert werden können. Der Fragestellung liegt die Annahme zu Grunde, dass eine nachhaltige Entwicklung mit *veränderten Denk- und Handlungsmustern* dringend erforderlich ist und Hochschulen – als Hubs für Forschung, Innovationen & Bildung – einen zentralen Hebelpunkt für eine nachhaltige Entwicklung der Gesellschaft leisten. Daher ist die Institutionalisierung von Nachhaltigkeitscurricula nicht nur gesellschaftlich gefordert, sondern auch in zahlreichen politischen Statements der Weltgemeinschaft, z.B. der UN und der UNESCO, festgeschrieben und durch das Sustainable Development Goal Nr. 4 "Quality Education" operationalisiert.

Bisherige Erkenntnisse *wie* eine solche Implementierung gelingen kann und welche Faktoren den Prozess befördern oder hemmen, liegen vor allem durch Fallstudien einzelner Hochschulen vor. Diese bilden wichtige Erkenntnisse, sind zum Großteil aber eher deskriptiv als analytisch und lassen Fragen nach der Generalisierbarkeit der Erkenntnisse offen – also inwiefern weitere Hochschulen sich an den jeweiligen Erfahrungen orientieren können.

An dieser Forschungslücke setzt die vorliegende Dissertation an. Durch eine Meta-Studie, den analytischen Vergleich existierender individueller Fallstudien, werden generalisierbare Erkenntnisse zum Implementierungsprozess von Nachhaltigkeitscurricula erforscht. In einem ersten Schritt wurde eine Grundgesamtheit von Fallstudien erhoben, um die Datengrundlage für tiefergehende Analysen zu generieren. In zwei weiteren Analyseschritten wurden, aufbauend auf der erhobenen Grundgesamtheit der Fallstudien aus Schritt 1, bestimmte Faktoren, die die Implementierung von Nachhaltigkeitscurricula fördern oder hemmen (Schritt 2), sowie spezifische Implementierungsmuster (Schritt 3) untersucht. Die folgenden Abschnitte erläutern Details und präsentieren einen Überblick über die jeweiligen Ergebnisse.

In einem ersten Schritt wurde eine Datenbank aus Englisch-sprachigen Fallstudien angelegt, die weltweit über Implementierungsprozesse von Nachhaltigkeitscurricula an Hochschulen berichten. Insgesamt wurden 230 Fallstudien identifiziert, wovon sich 133 Fallstudien im Kern mit der Implementierung von Nachhaltigkeitscurricula beschäftigen[6]. Eine bibliometrische Analyse der 230

[4] Nachhaltigkeitsbezogene Curricula werden hier verstanden als Kurse, Programme und Zertifikate alle Fachrichtungen, die sich in irgendeiner Form mit nachhaltigen Themen beschäftigen. Eine detaillierte Diskussion welche Typen von Bildung für Nachhaltige Entwicklung im Diskurs vertreten sind, findet sich in Abschnitt 3.1.

[5] Hochschule wird hier als Sammelbegriff genutzt für Universitäten, Fachhochschulen sowie weitere Institutionen, die mindestens einen Bachelor Abschluss anbieten.

[6] Eine detaillierte Beschreibung der Fallstudien Stichprobe und die Unterteilung in Untergruppen ist in Abschnitt 4.3 erklärt.

Fallstudien zeigt, dass dieses Forschungsfeld wächst. Der Diskurs ist vor allem durch Forschende und Fallstudien aus Nordamerika, Europa, Ozeanien und Asien geprägt, wobei Forschende und Fallstudien aus Südamerika und Afrika unterrepräsentiert sind. Zudem zeigt eine Zitationsanalyse, dass einige Fallstudien von Hochschulen die Erkenntnisse aus anderen Ländern miteinfließen lassen, während andere eher isoliert agieren. Dies lässt die Frage offen, inwiefern Hochschulen global miteinander im Austausch stehen und voneinander lernen, um die Implementierung von Nachhaltigkeitscurricula voran zu treiben.

In einem zweiten Analyseschritt wurden die qualitativen Daten der gesammelten Fallstudien (Stichprobe von 133 Fallstudien) anhand der Case-Survey-Methode (Art der Meta-Analyse) verglichen. Im Fokus standen dabei die Treiber und Barrieren der Prozesse, um Nachhaltigkeitscurricula an Hochschulen zu implementieren. Treibende und hemmende Einflussfaktoren auf den Implementierungsprozess von Nachhaltigkeitscurricula sind im Diskurs zur Bildung für Nachhaltige Entwicklung (BNE), speziell bezogen auf Hochschulen, ein theoretisch eingehend betrachtetes Feld. Hingegen fehlte bislang eine große Datenlage, um diese Hypothesen empirisch zu prüfen. Diese Forschungslücke füllt die vorliegende Arbeit, wobei die empirische Analyse ergeben hat, dass folgende Faktoren zu einer tiefen und breiten Etablierung von Nachhaltigkeitscurricula führen: Eine starke Unterstützung durch die Führungsebene (z.B. Präsidium, Dekanat); die Etablierung von Nachhaltigkeit sowohl in Lehre, Forschung, Campus, als auch der Austausch mit lokalen Akteurinnen und Akteuren; die formelle Partizipation interner (auch Studierende) und externer Akteurinnen und Akteure; und das Engagement von „Nachhaltigkeits-Champions" (change agents), die oft zuerst Nachhaltigkeitscurricula implementieren und gegen Widerstände ankämpfen. Weitere befördernde Faktoren sind: Strategische Planung, Koordination, Kommunikation, Vision, politischer Einfluss, eine günstige Gelegenheit (window of opportunity) (z.B. Umweltkatastrophe, Wechsel im Präsidium) sowie interdisziplinäre Begegnungsräume. Als stärkste Barrieren wurden folgende genannt: Fehlen von interdisziplinären Begegnungsräumen, fehlende Vision, fehlende Anreize, fehlende Ressourcen, überfülltes Curriculum, wenig unterstützende / zu bürokratische Organisationsstruktur.

Der dritte Analyseschritt baut ebenfalls auf der Datenlage der 133 Fallstudien auf und erforscht, ob bestimmte Typen bzw. Muster von Implementierungsprozessen auftreten. Durch die Analyse wurden sechs typische Implementierungsmuster identifiziert. Dabei führt das jeweilige Zusammenspiel der Faktoren zu einer Implementierung von Nachhaltigkeitscurricula in unterschiedlicher Tiefe und Breite, welche nachfolgend durch die absteigende Reihenfolge der Muster indiziert ist: (1) „a collaborative paradigm shift", (2) „bottom-up institutional change", (3) „top-down institutional change", (4) „the presence of many barriers that hinder institutional change", (5) „externally driven initiatives", and (6) „initiatives that are scattered due to a lack of coordination". Über alle Muster hinweg wurden zudem zwei Phasen identifiziert. Zum einen kann der Anstoß zur Implementierung von BNE nicht nur von internen, sondern auch von externen Akteurinnen und Akteuren initiiert werden. Zum anderen kann sich diese Initiierung dann sowohl „bottom-up", also durch Studierende, Lehrende, etc., als auch „top-down", also z.B. durch das Präsidium, oder auch von

beiden Ebenen gleichzeitig durchsetzen. Um den ersten Anstoß gewinnbringend zu nutzen, sind folgende Schlüsselfaktoren wichtig: Eine offene Kommunikationskultur zwischen allen Akteurinnen und Akteuren, in der Feedback und Reflektion willkommen sind und auch aktiv eingeholt werden. Die Entwicklung einer Vision, die von allen Beteiligten geteilt wird, kreiert Ownership und einen langfristigen Erfolg. Eine hohe Kollaboration aller Akteurinnen und Akteure, aber auch bestehender Initiativen führt zur Teilung von Wissen und weiteren Ressourcen. Dabei kann eine informelle Kollaboration und Kooperation teilweise die fehlende Unterstützung der präsidialen Ebene und/oder eine formelle Kommunikationsstruktur ausgleichen. Weiterhin führt die Entwicklung einer Strategie mit einzelnen Schritten und geteilter Verantwortung zu einer erfolgreicheren Implementierung von BNE an Hochschulen.

Die vorgestellten Erkenntnisse stellen eine ergänzende empirische Perspektive im Diskurs um die Etablierung von BNE an Hochschulen dar. Erstens sind die Fallstudien, die sich konkret mit den Implementierungsprozessen von Nachhaltigkeitscurricula befassen, das erste Mal als Forschungslandschaft analysiert worden. Auf dieser Grundlage können sowohl Forschende sowie Fördergebende über den Status Quo reflektieren und weitere Schritte planen, aber auch Praktikerinnen und Praktiker Beispiele auffinden. Zweitens bietet die vorliegende Dissertation die Möglichkeit die Vielzahl an Einzelfallstudien zu vergleichen und somit neue und generalisierbare Erkenntnisse zu entwickeln. Die empirische Analyse anhand von 133 Fallstudien zur Identifizierung von Schlüsselfaktoren, die eine Implementierung von Nachhaltigkeitscurricula fördern oder hemmen, stellt eine ergänzende Perspektive im Diskurs dar, der von theoretischen Überlegungen und individuellen Fallstudien geprägt ist. Damit eröffnet sich eine neue Perspektive auf Einflussfaktoren, die in jedem Kontext wichtig zu sein scheinen. Vor allem spezielle Muster an Implementierungsprozessen wurden bisher kaum und mit weniger Datensätzen untersucht. Diese Dissertation analysiert das komplexe Zusammenspiel aus über 100 Variablen und bietet damit eine der ersten Arbeiten, die Prozesse, die zu einer tiefen und breiten Implementierung von Nachhaltigkeitscurricula führen, besser zu verstehen.

In Zukunft werden Hochschulen eine noch größere Rolle auf dem Weg einer nachhaltigen Entwicklung spielen. Diese Dissertation bietet generalisierbare empirische Erkenntnisse wie es Hochschulen gelingen kann ihre Verantwortung wahrzunehmen und durch die Implementierung von BNE zu realisieren.

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ACU	Association of Commonwealth Universities
AUF	Agence universitaire de la Francophonie
BNE	Bildung für Nachhaltige Entwicklung
EFCA	Educating Future Change Agents (*research project, this work was embedded in)*
ESD	Education for sustainable development
HEI	Higher education institution
HE	Higher Education
HESD	Higher education for sustainable development
IAU	International Association of Universities
NGO	Non-governmental Organization
OL	Organizational learning
SD	Sustainable development
SDG	Sustainable development goal
SDSN	Sustainable Development Solutions Network
T&L	Teaching and learning
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCED	World Commission on Environment and Development
WSSD	World Summit on Sustainable Development

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After reading this dissertation, it should become clear that collaboration and support are critical to achieving sustainable transformation. This is especially true in an inter- and transdisciplinary research field. Therefore, this dissertation begins with an expression of sincere gratitude to all those who have accompanied and supported me on this PhD journey.

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Part I

Introduction, Overview, & Theoretical Background

1 On the Structure of this Dissertation

This thesis is a cumulative dissertation with a core that consists of several individual peer-reviewed research articles, which have been or will be published in various journals. The thesis forms the framework for these individual articles. It frames them in the context of the overall research inquiry, adds information that did not fit into the articles, synthesizes overarching research contributions, and thereby provides a comprehensive narrative while also outlining the connections between the various publications that were developed during this research endeavor.

Chapter 2 serves as the introduction to the thesis. It embeds the research inquiry in the social and political discourse and explains the urgency of implementing sustainability curricula at higher education institutions (HEIs).[7] The chapter not only highlights the societal need to implement sustainable issues more thoroughly in higher education but also touches on existing research gaps in order to help universities on their way to implementing education for sustainable development (ESD). Subsequently, the central research inquiry of this dissertation is stated.

Chapter 3 follows with an account of the scholarly discourse with the aim of providing the theoretical background of the thesis. First, a short explanation of what education for sustainable development entails and the various conceptualizations that can be found in the discourse is given. Second, the research discourse on the implementation of sustainability curricula at universities is outlined and structured, and research gaps are identified. In so doing, three central foci of this work are examined in greater detail: (1) the drivers and barriers that lead to or hinder the implementation of higher education for sustainable development (HESD), (2) the discourse on the issue of which general patterns can be identified in different types of implementation processes, and (3) a model that delineates and operationalizes different levels of ESD implementation.

Chapter 4 presents the research design. Previously derived research gaps are assigned to research questions. The case survey method is introduced as an overarching research method that addresses all posed questions, and the application of the individual steps of the case survey method is explained. Some explanatory material about the method is added that did not fit into the peer-reviewed articles.

Chapter 5 constitutes the core of the thesis and contains one research article in each of the three sub-chapters. A comparative table at the beginning of the chapter provides an overview of the foci of the three articles. Since these three articles each stand alone, it is inevitable that some elements that were presented in this framework paper in the previous chapters may appear redundant to the reader. Nevertheless, each article has a specific focus with complementary remarks on the theoretical discourse and (methodological) discussions. Each article also has its own unique set of results. However, in order to reduce redundancy as much as possible, cross-references to supplementary figures, documents, and appendices in the articles are slightly adjusted compared with the original

[7] Throughout the course of the work, the term *university* is used interchangeably with *higher education institution*, both of which refer to all types of higher education institutions.

articles. For instance, to increase readability, the appendices of each article are organized into a collected Appendix and renumbered accordingly. The original articles with the original appendices are each available online.[8]

Chapter 6 provides a synthesis of the *key* results of the three individual articles and thereby offers a response to the overarching research interest of the entire thesis. This chapter serves as a good starting point for gaining an overview of the findings.

Chapter 7 follows with a brief discussion of the results. More-detailed discussions of the results – including limitations – can be found in each of the individual articles.

Chapter 8 concludes by concisely highlighting the research contributions of this thesis. Moreover, an outlook toward future research opportunities is given.

The appendices provide greater details and additional documents that were published during the course of this research endeavor. Reference regarding which respective annexes provide extended data for which part of the research is provided throughout this thesis.

[8] See the overview of all publications on the first page after the title page or in the References for direct links to the original published research articles.

2 Introduction

"The coming decade will decide the course of the world. Systemic crises require new ways of thinking and acting. We need new ideas for our common future – and the courage to turn them into reality."

(The New Institute, 2020a)[9]

What makes the need for sustainable transformation so urgent is that we (i.e., humanity) are living in challenging times that need to be transformed in order to arrive at a future in which we act within a safe and just operating space while respecting planetary boundaries (Dearing et al., 2014; Leach et al., 2013; Raworth, 2012; Rockström et al., 2009). Various sustainability scientists have described the current era as the Anthropocene (Raworth, 2017; Steffen et al., 2018; Wals & Benavot, 2017). Exemplary challenges caused by humanity's pushing of planetary boundaries are illustrated by climate change and biodiversity loss, which entail several consequences, such as food insecurity, increasingly common environmental disasters (floods, earthquakes, and rising sea levels, all of which destroy living spaces), and refugee movements, all of which often go hand in hand with rising inequities and a distorted science–society interface (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES], 2019; United Nations High Commissioner for Refugees [UNHCR], 2019; United Nations [UN], 2020b; World Inequality Lab; World Meteorological Organization [WMO], 2020).

These global wicked sustainability problems are characterized by many complex and dynamic "interconnections among environmental, social, economic, cultural, ethical, etc. factors and there is no agreement on standards for successful outcomes" (Wals et al., 2016, p. 30). Consequently, these wicked sustainability problems allow for multiple definitions from various perspectives (Tomkinson, 2011).

Accordingly, what exactly sustainable development entails is characterized by manifold definitions in various contexts. Wals et al. (2016) explain the lack of a clear definition as follows: "It [sustainability] is influenced within society by a variety of perspectives, value orientations and beliefs (van Egmond & Vries, 2011; Vries & Petersen, 2009). It is characterised by indeterminacy, the impossibility of knowing in advance what the best approach or the best course of action is, and thus it evolves in an open-ended fashion" (Wals et al., 2016, p. 30).[10]

[9] *The New Institute* is "a mission-driven Institute of Advanced Study and a platform for change" located in Hamburg, Germany. The Institute "bring[s] together a community of globally concerned thinkers and practitioners from academia, the arts, activism, media, business, and politics" with the aim to "develop powerful visions to fundamentally reshape society and practical solutions to turn those visions into a reality" (The New Institute, 2020b).

[10] Wals et al. (2016) describe the evolution of dealing with these sustainability problems as a process in which it is assumed that the different dimensions and interests can be "balanced in good harmony and that there is some kind of optimum that allows everyone, everywhere to prosper and develop forever" (p. 26). However,

However, in order to provide a broad orientation in this thesis, sustainable development (SD) is viewed in line with the Brundtland Commission Report, which describes SD as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED World Commission on Environment and Development, 1987, ch. 2, para. 1). In this perspective, at least four dimensions of sustainable development – society, environment, culture, and economy – are intertwined (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2019).

With regard to the state of the Earth, in order to achieve sustainable transformation[11] at all levels of society, we critically need to question current living practices and to change existing patterns of action. According to Wals et al., there is a need "[…] *for new capacities* to handle complexity and to deal with fuzziness [i.e., global wicked sustainability problems]" (Wals et al., 2016, p. 30). Therefore, it is necessary – both in general and especially in education for sustainable development (ESD) – to reflect on what kind of knowledge and competencies are appropriate, needed, and should be developed. Reflecting on the past can help in understanding certain systems and interactions, but what sustainable transformation in the future will entail may need to be developed on the go and through reflection on both past and present knowledge.

As sustainable acting always begins with *new ways of thinking* about current practices and solutions, the role of education for sustainable development is to inform, educate, and train societies in regard to sustainable development because meaningful change requires new knowledge and/or unconventional thinking in order for *new ways of being (ontologies) and knowing (epistemologies) to be explored* in the world (Bengtsson et al., 2018; Lotz-Sisitka et al., 2015). This new way of thinking must include questioning, reflecting on, discussing, and negotiating, for example, the meaning of "good living" (Vanhulst & Beling, 2014), including current values, human-nature connectedness (Ives et al., 2017), and what it means to live within planetary boundaries (Rockström et al., 2009), which involves re-imagining the prevalent growth paradigm within the economic system.

In order to better understand and come to socially accepted solutions and new ways of being in the world, it is necessary to integrate knowledge from various academic disciplines and through collaboration with diverse stakeholders (Mochizuki & Yarime, 2016, p. 21). In order to translate this knowledge into action, change agents are needed – that is, people from varying disciplines who have the capacity to steer sustainable transformation (Brundiers et al., 2021; Hesselbarth & Schaltegger, 2014; Wiek et al., 2011). Change agents – who fill key positions in society – usually have higher levels

more recently, discourses have emerged that call this assumption into question and claim that a more-fundamental transition toward sustainable development with radically different principles is needed.

[11] The term *sustainable transformation* is used to refer to a more-radical transition toward a sustainable society. Nevertheless, in the context of some central documents and terminology from the global community, the term *sustainable development* is used to refer to the general (and not necessarily radical) process of change toward a sustainable society and world.

of education (Brennan, 2008; Orr, 2004); hence, higher education institutions are prime places to initiate sustainable transformation.

Globally, the vision of sustainable transformation and the role of (higher) education are reflected in the Sustainable Development Goals (SDGs) (UN, 2015). Between 2015 and 2030, the 17 Sustainability Development Goals (SDGs) – which were ratified in the United Nations General Assembly by 193 countries – featured most prominently in the global sustainability discourse. The 2030 Agenda for Sustainable Development is targeted at all countries and all people and centers around "action for people, planet and prosperity" with the aim of "eradicating poverty in all its forms and dimensions, including extreme poverty, [which] is the greatest global challenge and an indispensable requirement for sustainable development" UN (2015, p. 1). In this context, the UN defined 17 Goals that center around the economic, social, and environmental dimension of SD as a framework for concrete implementation at various levels.

As explained above, education for sustainable development plays a leading role in moving toward sustainable development. This role is highlighted by SDG No. 4 (Quality Education), which is seen as a main point of leverage toward sustainable development and a critical factor in reaching the other SDGs (Sachs et al., 2019; UNESCO, 2020, p. 14). Sub-goal No. 4.7, in particular, states that "[b]y 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 and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development" (UN, 2015, p. 17).

At the national level, countries have developed and implemented their own national action plans, goals, laws, and guidelines, and they will continue to further their efforts in these areas.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) has pushed forward the implementation of ESD in different educational sectors – ranging from elementary schools to higher education and informal education – since the Johannesburg World Summit on Sustainable Development (WSSD) in 2002. The Brundtland Report (WCED World Commission on Environment and Development, 1987) and Agenda 21 (UNCED, United Nations Conference on Environment and Development, 1992) – which was ratified at the United Nations World Conference on Environment and Development, held in Rio de Janeiro Rio (1992) – are considered a prelude to the discourse on the topic of broader global (political) sustainability (education).

In order to promote the integration of ESD in every region of the world, the United Nation's World Decade on Education for Sustainable Development (2005–2014) was launched (Michelsen, 2016, p. 40). To continue the actions that began during the ESD decade, UNESCO further created the Global Action Program (GAP), which ran from 2015 to 2019 with the goal to "empower learners to transform themselves and the society they live in by developing knowledge, skills, attitudes, competences and values required for addressing global citizenship and local contextual challenges of the present and the future […]" (UNESCO, 2016, p. 5). Currently, the #ESD for 2030 Roadmap –

developed under the leadership of UNESCO – has laid the groundwork for further development over the next 10 years (UNESCO, 2020).[12]

Higher education institutions, in particular, act as a catalyst for sustainable development as they not only educate future change agents and prepare graduates and new leaders to pursue sustainability in their various professions, but they also generate new innovative research that addresses global challenges and transfers new knowledge via community engagement within governments, in the private sector, and in civil society. Thus, according to a joint statement by several higher education associations, "None of the 17 Sustainable Development Goals (SDGs) can be achieved without the contribution of higher education and research" (International Association of Universities [IAU] et al., 2019). Additionally, the International Association of Universities (IAU)[13] stresses that "[…] it is critical that higher education institutions understand and accept their responsibility within the broader context of social and economic development, and the building of democratic, equitable and ecologically-minded societies" (IAU, 2010, para. 1). Consequently, the strategic plan of the IAU for 2016–2021 lists ESD one of six strategic objectives (IAU, n.d.).

In order to complete the different tasks that higher education institutions (HEIs) perform for society, sustainability can be established in research, campus operations, and outreach in addition to actual teaching and learning.

But how do HEIs complete this challenging task of implementing sustainability, especially in the areas of teaching and learning?

Various (mostly single) case studies have shown that some universities across the world have begun to implement sustainability in their institutions – especially in cross-curriculum- or specific courses and/or programs (Charli-Joseph et al., 2016; Peet et al., 2004; Tamura & Uegaki, 2012). However, more-profound progress is being made in niches of higher education via attempts to institutionalize sustainable development at an institution's core (i.e., in all areas of the HEI, which is referred to as the "whole-institution approach" (D'Andrea & Gosling, 2005)) and to implement sustainability topics in an institution's vision and ethos (Ferrer-Balas et al., 2004; Gudz, 2004; Yarime et al., 2012). However, studies have concluded that specific implementation processes and outcomes differ significantly, and many authors have described them as insufficient (Lozano et al., 2015; Lozano & Young, 2013; Wals, 2009). For instance, in Germany, a recent study revealed that the implementation

[12] A detailed overview of how ESD has been implemented in policy, politics, and polity is outlined, for example, in Michelsen 2016. Recent information and an overview of guidelines and publications on HESD and the SDGs can be found, for example, at the homepage of the International Association of Universities (https://www.iau-hesd.net). More details on the relationship between HEIs and the SDGs can be found in a report and guideline from the Sustainable Development Solutions Network (SDSN), SDSN Australia/Pacific (2017).

[13] "The International Association of Universities is an international non-governmental organization and an official partner of UNESCO (Associate Status) that recognizes the key role higher education (HE) plays in the overall process of achieving sustainable development. Currently, IAU gathers more than 640 Members (Institutions, Organisations, Affiliates and Associates) from over 120 countries (June 2020)." International Association of Universities (IAU) (n.d.)

of higher education for sustainable development (HESD) is slow, and – on the basis of an analysis of key documents – comprehensive implementation has not yet been achieved (Singer-Brodowski et al., 2019, p. 492).

One possible reason for the slow implementation of sustainability curricula at universities seems to be the lack of knowledge about the conditions and strategies of successful (deep-rooted and comprehensive) implementation processes. This lack of knowledge is also reflected in the current research landscape. Individual implementation processes are largely described in single case studies. Only a few studies have conducted analytical and comparative research on how these processes take place. All too often, it remains unclear which factors have led to the implementation of sustainability curricula, what level of sustainability curricula has been implemented, and which contexts have given rise to the implementation processes. A further remaining research gap exists regarding whether patterns of similar implementation processes or influencing factors exist that can lead to a similar level of implementation. To answer these questions, a systematic meta-analysis of the large volume of single case studies is necessary (Barth & Thomas, 2012; Fien, 2002). An investigation into possible patterns and their key drivers and barriers across different contexts that is supported by empirical evidence and robust data is currently lacking in the discourse on HESD. It is therefore necessary to explore which strategies and processes have worked and which could be transferred to other HEIs. These needs serve as the starting point of the present dissertation, which is guided by the following research inquiry:

What generalizable drivers and barriers influence more comprehensive sustainability curriculum change in higher education institutions, and how could a better understanding of specific implementation patterns enable sustainability curriculum change in higher education institutions?

In other words, how can robust evidence be found that can enable higher education institutions to shift from a perspective of responsibility to one of response-ability?

The aim of this doctoral research project is hence to systematize and illustrate generalizable key drivers and barriers as well as specific implementation patterns across different contexts. The approach of using the case survey method (a meta-analytical approach) thereby features uniquely in the present discourse and provides additional and novel insights. A comprehensive consideration of such complex transformation is ensured by applying an analytical scheme that consists of 111 variables that represent the complexity inherent in the implementation process of HESD.

The results provide analytical insights into and practical guidance on how key stakeholders can steer and coordinate actions the lead to the implementation of sustainability curricula in higher education. The findings of this research project serve to inform (a) all internal and external stakeholders of higher education institutions who wish to strengthen the implementation of sustainability curricula at their institutions and (b) other experts in highly relevant positions. Furthermore, the findings stimulate reflection on the current discourse on HESD implementation processes.

3 Theoretical Background

While the introduction of this dissertation revealed why education for sustainable development (ESD) is important from a socio-political point of view and why higher education institutions are important leverage points for sustainable development, this chapter provides the theoretical basis for specifically addressing the question of *how* ESD can be implemented in higher education curricula.

Chapter 3.1 presents the discourse on what education for sustainable development actually means and on what different ESD characteristics exist both in the literature and in practice. These characteristics are relevant as the present study deals with the worldwide implementation of ESD and analyzes different types of sustainability curricula and different teaching- and learning approaches.

After clarifying what is meant by *sustainability curricula* in this dissertation, Section 3.2 focuses on the main topic: the implementation of sustainability curricula at HEIs. First, an overview of the research landscape is given – that is, which aspects of the implementation of sustainability curricula at universities have been researched thus far. In this overview, six main research areas are highlighted. Since these research foci developed in an interdisciplinary way, a short explanation is provided regarding the disciplines from which the different insights stem. Subsequently, the primary focus is on three of the six areas identified in this dissertation: (1) the factors that promote or hinder the implementation of sustainability curricula, (2) the different types or patterns of implementation processes that result from a different interplay between drivers and barriers, and (3) the way in which the depth and breadth of sustainability curriculum implementation can be analyzed. In each case, the current research discourse is presented in an introductory manner (for more details, see the respective research articles), the concepts used in this dissertation are clarified, and research gaps are identified.

3.1 Education for Sustainable Development

Since definitions of sustainable development are characterized by complexity and ambiguity and sustainability challenges have been described as wicked problems (i.e., problems that allow multiple definitions from multiple perspectives and therefore have different foci and possible solutions), the approach to forming a comprehensive definition of education for sustainable development (ESD) is also highly challenging.

What exactly is understood by ESD is hence characterized by a complex multidisciplinary discourse in different languages (Holdsworth & Thomas, 2020) and a variety of different contexts (historical, geographical, political, social, environment) (Transforming Education for Sustainable Futures [TESF], 2020). In a discussion paper, the TESF project provided an overview of the different ESD conceptualizations that appear in the discourse, including human-capital approaches, rights-based approaches, capability approaches, environmentally oriented approaches, decolonizing perspectives, and the concept of education for sustainable futures (for greater detail, see TESF,

2020). In order to create a shared understanding of ESD in the global discourse that includes varying contexts, the TESF project used these various conceptualizations of ESD to create the following definition: "[ESD means] access to a good quality education for all that can facilitate existing and future generations of learners across the lifespan, in formal and informal settings, to realise the rights, freedoms and capabilities they require to live the lives they have reason to value and to protect and co-evolve in a more harmonious relationship with the natural environment of which human beings are an integral part so that natural and social systems may flourish" (TESF, 2020, p. 21).

UNESCO (2020) has stated that "ESD employs action-oriented, innovative pedagogy to enable learners to develop knowledge and awareness and take action to transform society into a more sustainable one" (p.3) and stresses that "ESD is a lifelong learning process" (p.8). "[C]ross-cutting competencies in cognitive, socio-emotional and behavioural dimensions of learning" (p.14) and a "particular emphasis on competencies related to empathy, solidarity and action-taking" (p.14) are thereby inherent to ESD.

Solutions to sustainable challenges exist along a continuum on at least two dimensions. On the one hand, there are short- vs. long-term solutions, and on the other hand, there are already-established solutions that must be implemented vs. unknown solutions.

Accordingly, two basic strands of ESD can be distinguished: the instrumental approach and the emancipatory approach (Barth, 2015; Wals et al., 2008; Wals & Jickling, 2002). The instrumental approach is mainly concerned with determining which competencies or learning outcomes must be developed assuming that a certain set of knowledge (and values) is necessary for sustainable development. The emancipatory approach focuses on the freedom, self-directedness, and reflection of the learner. This approach emphasizes the notion that the information necessary to solve certain (future) sustainability problems is currently unknown and that the criteria for sustainability are subject to change depending on time, place, and context and therefore cannot be "taught" (Wals et al., 2016, 26f.).

Furthermore, Vare and Scott (2007) coined the terms ESD 1 and ESD 2, which correlate with the conceptualization of an instrumental and an emancipatory approach to ESD, respectively, and the authors state that both forms complement each other. Vare and Scott view " […] ESD 1 as the promotion of informed, skilled behaviours and ways of thinking […] [that are] useful in the short-term where the need is clearly identified and agreed [on], and [they view] ESD 2 as […] [the] building [of the] capacity to think critically about what experts say and to test ideas, [to] explor[e] […] the dilemmas and contradictions inherent in sustainable living" (Vare & Scott, 2007, p. 1).

Since most challenges regarding sustainable development require transformative action (including changing paradigms) rather than adaptive action, different levels of learning and reflection are further distinguished in the discourse on ESD. One prominent distinction exists regarding the continuum between single- and triple-loop learning (Barth, 2015, 167ff.; Sterling, 2004), for which the foundation was laid by Argyris and Schön (1978). Single-loop learning describes "doing things better" while highlighting certain behaviors that, for example, reduce the environmental footprint. As this

type of learning is not sufficient for achieving sustainable transformation, double-loop learning centers around "doing better things" by reflecting on one's own values. Triple-loop learning focuses on strongly challenging one's own persistent worldviews and centers around "seeing things differently." A similar distinction groups learning into first-order-, second-order-, and third-order varieties (Mochizuki & Yarime, 2016; Sterling, 2004). As Sterling (2004) further explains, "The logic of this [triple-loop- or third-order learning] is that learning *within* [a] paradigm does not change the paradigm, whereas learning that facilitates a fundamental recognition of [a] paradigm and enables paradigmatic reconstruction is by definition transformative" (Sterling, 2004, p. 55).

Another common distinction used in describing the different states of ESD according to progressive levels of learning was made by Sterling (2001) and Sterling and Thomas (2006) and consists of (1) education about sustainability, (2) education for sustainability, and (3) education as sustainability or sustainable education. Education *about* sustainability leaves current paradigms unchallenged and is based on the transmission of facts about sustainability. Education *for* sustainability implies significant adaptive changes to a curriculum through which sustainability topics are usually "built-in" and current assumptions are critically questioned in order to develop a greater understanding (a more-learner-centered approach). Finally, *sustainable education* is a paradigm shift that places sustainability principles, ethics, and values at the core of the curriculum (Barth & Michelsen, 2013; Sterling, 2001). This categorization is akin to the levels of learning described above – that is, the continua of single- and triple-loop learning and of first- and third-order learning, respectively.

More recently, the notion of transformative, transgressive learning (T-learning) (Bengtsson, 2019) has emerged. T-learning criticizes the "current tendency in sustainability science and learning to rely on resilience and adaptive capacity building and argues that in order to break with [the] maladaptive resilience of unsustainable systems it is essential to strengthen transgressive learning and disruptive capacity-building" (Lotz-Sisitka et al., 2015, p. 73).

In practice, however, ESD initiatives, courses, and programs usually fluctuate on the continuum between instrumental and emancipatory approaches (Barth, 2015). However, ESD has been consistently criticized for allegedly instrumentally indoctrinating learners into a system with certain values. Barth and Michelsen (2013) responded to such criticism by revealing that education is always bound to certain historical contexts. Therefore, ESD cannot be neutral in terms of values, but the learner's critical reflection on these values should always be supported in ESD. Papenfuss et al. (2019) place the relationships in a matrix with transmissive and transformative pedagogies on one axis and instrumental and emancipatory pedagogies on the other axis and argue that even an instrumental approach can be transformative if reflexivity is inherent.

In an effort to more-precisely define what graduates (or other learners) should learn, a further debate exists regarding – inter alia – which specific competencies, capabilities, and skills should be developed. This debate is made more difficult by the existence of different interpretations of the terms "competence," "capability," and so on. For example, the term competence has been criticized for being associated with a desired behavior (instrumental), and the suggestion to reject it has therefore been put forward (Barth, 2015, p. 58; Wals & Jickling, 2002). On the other hand, Wals et al.

(2016) "do not consider 'competence' as an analytical term that cuts up human behaviour into smaller pieces that can somehow be measured or captured in a rubric. Rather [...] [they] view sustainability competence as a relational, contextual and emergent property. As such[,] sustainability competence refers to a way of knowing, doing, being and transforming in[to] action that leads to a temporary outcome that is considered the most sustainable given what we know, value and strive" (Wals et al., 2016, p. 28). In a recent article, Holdsworth and Thomas (2020) explained the different usages of these terms in the Australian and German education systems and concluded that "[i]n the European context, there is a relatively broad interpretation of the concept of 'competencies' [...] [that] encompass[es] much of the breadth of capability," whereas a "competency-based approach to education, within the Australian context, represents prescribed outcomes and actions informed by an educator's values and the values of the relevant industry within a predefined context" (Holdsworth & Thomas, 2020, 13f.). In an international hermeneutic-philosophical analysis, Shephard et al. (2019) revealed misunderstandings and contradictions in the current debates around the terminology of competence and capability and concluded that a common terminology should be found in order to implement ESD successfully.

Various concepts that focus on competences or capabilities for sustainable development have, for instance, been described by Rieckmann (2012) and Lozano et al. (2012). Wiek et al. (2011) reviewed various concepts of competencies for SD and synthesized them in a well-known framework of five key competencies: a systems-thinking competency, a strategic-thinking competency, an interpersonal competency, a future-thinking competency, and a values-thinking competency, all of which accumulate in an overarching problem-solving competency. This framework was recently re-evaluated by a Delphi study that (a) proposed a hierarchy in which values-thinking acts as an underlying competency and (b) added an implementation competency and further discussed the addition of an intrapersonal competency (Brundiers et al., 2021).

Special teaching- and learning formats are particularly important and well suited to developing sustainability competencies (Sterling & Thomas, 2006). This strand of research is primarily concerned with the level of individual courses and investigates innovative teaching- and learning formats as well as how to assess such sustainability competencies (Birdman et al., 2020; Brandt et al., 2021; Dlouhá & Burandt, 2015; Foucrier, 2020; Halberstadt et al. 2019; Konrad et al., 2021; Redman, 2020).

At the curriculum level, the focus is more on enabling ESD courses and programs and on a comprehensive implementation of ESD. Since this thesis analyzes very different sustainability curricula and their implementation processes via a meta-analysis, the diversity of the different ESD approaches and of the teaching- and learning formats that are applied in courses and programs is also recognized. Therefore, when discussing sustainability curricula, no specific ESD approach or set of competencies is intended; rather, "sustainability curricula"[14] is used as a general term to describe

[14] In some published research articles, "sustainability curricula" is used interchangeably with "sustainability curriculum."

a formal teaching- and learning approach (i.e., course(s) or program(s)) that occurs in the context of ESD.

3.2 Research Landscape of Sustainability Curriculum Change in Higher Education

Shifting higher education curricula toward a focus on more-deeply rooted and more comprehensive implementation of sustainability issues is very complex and challenging. Not only are universities highly reluctant to change (particularly due to academic freedom) (Evans & Henrichsen, 2008), but many different actors exist with different values, opinions, and interests when it comes to anchoring new topics in the curriculum (Blanco-Portela et al., 2017; Cortese, 2003; Lattuca & Stark, 2009; Thomas, 2016). In order to change curriculum structures with regard to education for sustainable development (ESD) and to develop or renew appropriate teaching formats, a variety of factors and stakeholders form a complex network of interactions that leads to changes in sustainability curricula.

In the following section, the term "sustainability curriculum implementation process" is used interchangeably with the term "implementation process of sustainability curricula" to refer solely to the level of education, and both terms are defined as "[. . .] the development and implementation of new approaches to teaching and learning 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). However, if ESD is embedded in the core of an HEI, sustainability topics will permeate the entire institution (education, research, campus operations, outreach) in terms both of teaching- and learning activities and of the process of institutionalizing sustainability curricula. In this context, the "implementation process" is understood to be institutional and to have various drivers and barriers. The terms "sustainability curriculum" and "sustainability curricula" refer to the variety of ESD courses and programs and always imply that these processes take place within higher education.

Since the implementation of sustainability curricula at universities is highly complex, it is critical to better understand the various influencing factors and their mechanisms of action. Over the past 15 years, a growing number of studies have focused on such implementation processes (Barth, 2015; Blewitt & Cullingford, 2004; Corcoran & Wals, 2004; De La Harpe & Thomas, 2009; Lozano, 2006; Thomas, 2004).

In the field of higher education for sustainable development (HESD) curriculum change, several strands of research can be distinguished that describe, analyze, and also – to some degree – design a sustainability curriculum implementation process. All these strands of research offer different perspectives and insights and reveal manifold connections between one another (see Figure 3.1). These perspectives involve (a) the type of integration of ESD into the curriculum (Lambrechts et al., 2013), (b) the level of depth of the curriculum change (Eckel et al., 1999; Sterling & Thomas, 2006), (c) the stages and dynamics of the curriculum change (including the history and traditions of HEIs) (Eckel et al., 1999; Hoover & Harder, 2015; Krizek et al., 2012; Lattuca & Stark, 2009), (d) the impetus

for change (Fumasoli & Lepori, 2011; Lattuca & Stark, 2009), (e) specific drivers and barriers that influence the sustainability curriculum process (a dominant strand that includes – inter alia – various stakeholders, interests, and attitudes) (see Section 3.2.1), and (f) various patterns of implementation processes that are formed via connections between the aforementioned influences (see Section 3.2.2).

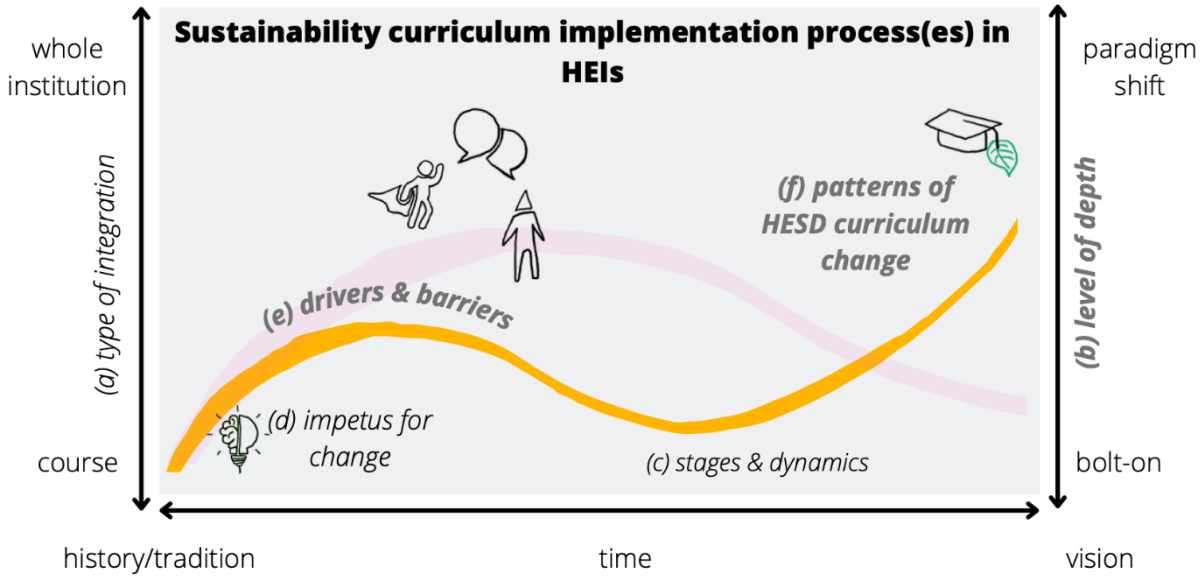


Figure 3.1 Dimensions of sustainability curriculum implementation process(es) in higher education institutions (HEIs) (author's own elaboration)

As this study centers around the question of which *drivers and barriers* lead to a *high level of sustainability curriculum implementation* and to distinct *implementation patterns*, focus is deliberately placed on these three strands of research. In order to provide a basis for the research design of this thesis, the current discourse in each strand is described, and respective research gaps are mentioned. However, it should be noted that all aforementioned dimensions are connected with one another and are needed to describe a holistic change process. Therefore, the remaining dimensions are presented as further variables in the subsequent analysis (see Section 4.3 and Appendix No. 5, Section 10.5). In order to understand where these individual dimensions and research foci stem from, a brief outline of the disciplines and the respective prominent theories from which insights originate is presented before turning to the discourse on the level of sustainability curriculum change, on the respective drivers and barriers, and on the patterns of the distinct implementation processes.

Previous research on implementation processes of sustainability curricula has built on many different (inter)disciplinary theories on how change occurs. Three main disciplinary perspectives can be distinguished:

(1) *General research on curriculum change*, which stem from educational sciences; (2) *theories of organizational change*, the majority of which stem from economics and from studies on the

implementation of innovations in organizations; and (3) theories on how *transformational change* toward a sustainable development takes place in systems and/or communities, a perspective that stems from the sustainability sciences in the last two decades.

The present research can thus be roughly situated between (a) general curriculum change theories; (b) organizational-learning- and organizational-change-management theories; and (c) sustainability science, which provides the framework for this dissertation via research on what sustainable transformation entails and on the need for (H)ESD as well as via theories on how to achieve transformational change toward sustainable development (see Figure 3.2).

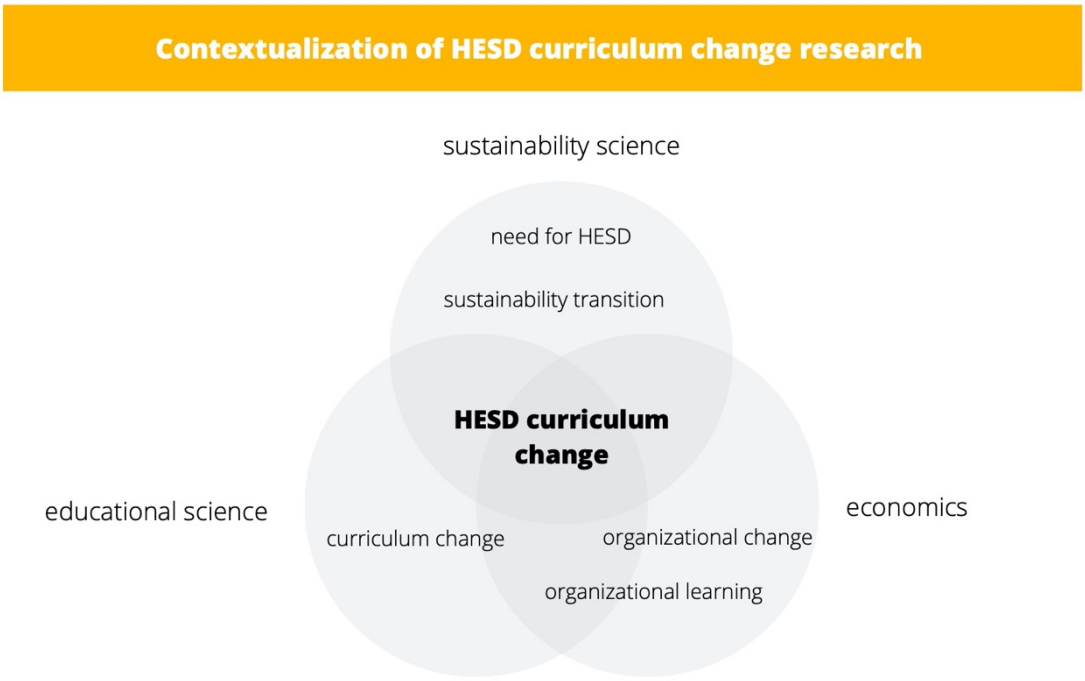


Figure 3.2 Theoretical contextualization of curriculum change research in higher education for sustainable development (HESD) (author's own elaboration)

The following digression outlines some background information on the theoretical concepts that have been applied to sustainability curriculum change in higher education institutions in existing research.

General curriculum change

The general theories on *curriculum change* serve as the basis of research on higher education for sustainable development as they highlight the complexity of this change. Different interacting dimension are emphasized, including the breadth, depth, level, and time (history and tradition) of the change as well as internal vs. external stakeholders, various levels of action (local, regional, national), and planned change vs. diffusion (Cuban, 1999; Fullan, 2007; Lattuca & Stark, 2009). Eckel and Kezar (2003) further stress that in order for lasting transformational curriculum change to occur, "the alternation of institutional culture and ways of thinking" (p.40) is a critical characteristic. The authors further cite Schein (2004, first published 1992) and explain that a "[b]ehaviour change can be coerced, but it will not last once the coercive force is lifted unless cognitive redefinition has preceded or accompanied it" (Schein, 2004, p.325). Eckel et al. (1999) additionally provide a typology of four different types of change on a matrix between the two axes of depth and pervasiveness that ranges from "adjustments" to "transformational change" (Eckel et al., 1999). The alteration of underlying assumptions and the mental models of the involved stakeholders are key to transformational change. In order to assist in altering institutional culture, Eckel and Kezar (2003) emphasize the importance of open communication between various stakeholders with varying ideas, which is important in constructing new identities collaboratively.

Organizational learning / change

The perspective of learning from one another within organizations as entities is explicitly elaborated in theories on organizational learning (OL). As Sylvestre and Wright (2016) aptly put it, "navigating OL literature is challenging" (p. 304). The discourse on the topic emerged in the 1980s, mostly within business studies as a requirement to adapt to new external factors (Cebrián et al., 2013). In the discourse on OL, varying approaches have been discussed. Basten and Haamann (2018) provided a literature overview by synthesizing 18 OL approaches.

In order to explain key elements and insights that stem from research on *organizational learning / management*, two studies from the HESD discourse that reviewed a variety of different theories and models are summarized here.

In a conceptual review, Cebrián et al. (2013) investigated organizational learning theory (as labeled by Argyris and Schön, 1978), expansive learning theory (Engeström, 1987), the learning organization (Senge, 2006, first published in 1990), and transformative learning theory (Mezirow, 2009) and synthesized the concepts in a theoretical framework designed explicitly to deal with HESD due to their belief that these theories complement one another. In the following section, the conceptualization created by Cebrián et al. (2013) is briefly summarized and complemented with additional literature where necessary in order to clarify concepts and terminology.

Organizational learning as a term was coined by Argyris and Schön in 1978 and occurs when "[i]ndividuals within an organization experience a problematic situation and inquire into it on the organizational behalf. They experience a surprising mismatch between expected and actual results of action and respond to that mismatch through a process of thought and further action that leads them to modify their images of organization or their understandings of organizational phenomena and to restructure their activities so as to bring outcomes and expectations into line, thereby changing organizational theory-in-use" (Argyris & Schön, 1996, p. 16). The organizational capacity to learn thereby relies on individuals' capacity to do so (Cebrián et al., 2013). Argyris and Schön (1996) distinguish two different types of learning: single-loop learning, which is "instrumental learning that changes strategies of actions or assumptions [about] underlying strategies in ways that leave the values of a theory of action unchanged" (Argyris & Schön, 1996, p. 20), and double-loop learning, which involves a feedback loop that "connects the detection of error not only to strategies and assumptions of effective performance but to the values and norms that define effective performance" (Argyris & Schön, 1996, p. 23). In the subsequent discourse, building on the work of Argyris and Schön, the term "triple-loop learning" evolved, which refers to "learning about the process of learning" (Tosey et al., 2012, p. 295). However, Tosey et al. (2012) have stated that varying conceptualizations and similar theories with different terminologies are inherent when using the terms single-, double-, and triple-loop learning. At the core of Argyris and Schön's theory is the ability to reflect on existing mental models in order to achieve transformative change.

Cebrián et al. (2013) argue that the model created by Argyris and Schön (1978) is not sufficient to conceptualize HESD change and that cultural and historical contextual factors are not adequately represented in this model. They therefore suggest integrating *expansive learning theory* (Engeström, 2001) into a novel OL framework in order to highlight the notion that "cultural and historical factors shap[e] the activity itself" (Cebrián et al., 2013, p. 295). Within expansive learning theory, the focus lies on activity systems – that is, on teams and organizations rather than on individuals. Existing contradictions, dialogue, multiple perspectives, and interacting activity systems (Engeström, 2001) are thereby highlighted in order to enable reflection and learning.

In *Senge's Fifth Discipline* and the learning organization, the focus lies on the transformation of existing worldviews (paradigm shift) as well as on dialogue and collaboration (Senge, 2006). To achieve such a learning organization, Senge (2006) developed five learning disciplines, which are explained in relation to HESD in greater detail by Cebrián et al. (2013).

The last theoretical framework that Cebrián et al. (2013) added to their OL framework for achieving HESD transformation is *transformative learning theory* for adult education (Mezirow, 2009). Here, the focus lies on the learning process, through which "participants challenge their existing worldviews, beliefs, feelings, and assumptions based on past experiences. By a process of critical reflection[,] decisions are taken collectively about new ways of understanding" (Taylor, 2009 in Cebrián et al., 2013, p. 297). In contrast to the previous theories, affective and emotional components are emphasized in this framework in addition to critical reflection and dialogue in the process of achieving transformative change.

In a second study, De La Harpe and Thomas (2009) investigated conditions for embedding HESD by drawing on the literature on both general curriculum change and *organizational change*. The authors described the well-known model on *organizational change management* by Kotter (1996) and applied it (in addition to other conditions) in a survey on academic perceptions of two HEIs. According to De La Harpe and Thomas (2009), the eight-step generic-change model by Kotter (1996) has been used increasingly often in higher education contexts. The steps of the model include (1) establishing a sense of urgency, (2) creating a guiding team, (3) developing a vision and a strategy, (4) communicating the changed vision, (5) empowering comprehensive action, (6) generating short-term wins, (7) consolidating gains and producing more change, and (8) anchoring new approaches in the broader culture. After a few years of various new change-management models and failed change processes, a human factor – namely emotions – was added to each of the steps (Kotter & Cohen, 2002). In two surveys that explored academic perceptions of the conditions that are necessary for sustainability curriculum change within two HEIs, De La Harpe and Thomas (2009) found support for Steps 2, 3, and 5 of the model on organizational change management created by Kotter (1996).

In a further study, Verhulst and Lambrechts (2015) conducted a conceptual and empirical study on how to embed HESD from the perspective of *organizational change management* and focused on human factors (i.e., resistance, communication, empowerment and involvement, and organizational culture). The authors presented and applied a conceptual model for a Belgian HEI with the goal of better understanding the underlying reasons behind certain barriers while also highlighting the importance of ongoing support for sustainability champions.

Sustainability science

Sustainability science is the third branch of research in which the present study is embedded. First, sustainability science reveals the urgency for ESD as well as the topics that can be embedded in different curricula. Additionally, sustainability science offers theories and considerations regarding how the transition toward sustainable transformation can take place. In the context of HESD curriculum change, several theories have been applied thus far. First, Lidgren et al. (2006) conducted a case study at the University of Lund on embedding HESD using Meadows' *Leverage Points: Places to Intervene in a System* (Meadows, 1999). The authors concluded that Meadows' tool is useful for systematically discovering and overcoming barriers, and they provided six recommendations for how to intervene at different levels within an HEI in order to overcome barriers. Next, based on the literature on *transition management*, Stephens et al. (2008) developed five critical issues for which HEIs can serve as change agents for sustainability. Finally, in a comparative case study, Pardellas Santiago et al. (2017) investigated the ability of Transition Communities at three HEIs to steer ESD using *Transition Network methodology*. The authors concluded that a certain "glass ceiling" was evident and that the application of transition methodology was unable to break through current organizational and cultural structures that inhibit more comprehensive implementation of sustainability curricula.

In sum, navigating (underlying) theories relating to steering sustainability curricula in higher education – particularly with a processes-oriented focus – is challenging. Every theory or concept

offers a different way of conceptualizing the change process and goes hand in hand with varying foci in terms of influencing factors; however, in most theories, communication, collaboration, and leadership are highlighted, even if these areas have different conceptual emphases. Moreover, some theories stress the need to think about emotions, reflexive practices, and altering institutional cultures in order to reach long-lasting change. For research on sustainability curriculum processes in HEIs, influencing factors seem more or less to be collected from various theories and reassembled as lists without connection to these theories. Only a few (case) studies have aimed to link change theories with HESD processes, and most examples are mentioned above.

3.2.1 Drivers of and Barriers to Sustainability Curricula Change

Drivers of and barriers to implementing sustainability curricula represent a dominant strand of research within the landscape of higher education for sustainable development (HESD).

These driving and hindering factors for sustainability curriculum change have been studied in:

- Literature reviews: Many literature reviews have derived mostly laundry lists of drivers and barriers (e.g., Velazquez et al., 2005), whereas a collection of research articles edited by Holmberg and Samuelsson (2006) mapped a base by explaining why certain factors are central to HESD implementation.
- Theoretical logic models: Few attempts have been made to structure these drivers and barriers and their connections. In a theoretical logic model, Barth (2015, ch. 11) explained how these drivers and barriers are connected with one another (see 3.2.1.1).
- Single case studies: The majority of research on drivers and barriers has consisted of numerous – mostly descriptive – single case studies that describe implementation processes of sustainability curricula (e.g., Cebrián, 2017; Segovia & Galang, 2002; Trechsel et al., 2018; Verhulst & Lambrechts, 2015). These case studies have been critiqued for being rather descriptive and for insufficiently reflecting an analytical and methodological approach (Corcoran et al., 2004).
- Comparative case studies: Only a few (analytical) small-N comparative case studies have added to the understanding of sustainability curriculum change processes in HEIs across different contexts (e.g., Banga Chhokar, 2010; Davison et al., 2013; Ferrer-Balas et al., 2008).
- Surveys: Recently (during the development of the present work), surveys have added another perspective from a larger international case sample. However, these insights are rather descriptive and place less focus on a comprehensive analysis of the implementation process of sustainability curricula in HEIs. One survey focuses on barriers to adopting innovation and sustainability in universities (Ávila et al., 2017), while another uses the "Sustainability Tool for Assessing UNiversitites' Curricula Holistically" (STAUNCH) to assess whether and how sustainability curricula are taught (Lozano & Barreiro-Gen, 2019).

Since the research field is largely characterized by individual case studies from different disciplines, these studies are quite diverse and scattered and use a variety of approaches. In order to generate

more-general findings, various researchers have called for a meta-study (Barth & Thomas, 2012; Fien, 2002).

Such a meta-study would have at least 2 purposes: First, it would enable reflection on the current research landscape in order to reveal what remains to be researched and to identify blind spots in which single case studies could add to a better understanding of sustainability curriculum implementation processes.

Second, an analysis of this large number of case studies would allow for new insights into the most-common key drivers and barriers and into the contexts (interactions of different key drivers and barriers / patterns) in which these drivers and barriers have a decisive impact on the implementation process.

The present dissertation builds on the call for a meta-analysis by addressing the following research gaps.

→ Gap 1: A global and systematic overview of the differentiated and fragmented field of (mainly individual) case studies is missing that would enable reflection on both the research field and sustainability curriculum implementation processes across different contexts.

→ Gap 2: Empirical evidence – based on a medium N[15] of case studies (meta-study) – of key drivers and barriers across different contexts is missing.

3.2.1.1 Used Analytical Scheme of Drivers and Barriers

In this thesis, the logic model of drivers and barriers synthesized by Barth (2015, ch. 11) – which describes intervening factors for implementing sustainability curricula – provides the basis for the analysis of drivers and barriers (see Figure 3.3). The following section includes a rough overview of the central influencing factors that this model and most other common lists of drivers and barriers contain. However, detailed descriptions are provided in Barth (2015, ch. 11), the respective research articles of this dissertation (see Sections 5.3 and 5.4) as well as in the developed analytical scheme (Appendix No. 5, Section 10.5), which provides additional information and detailed definitions of each influencing variable. Nevertheless, the following section provides an overview of the layers and moderators inherent in sustainability curriculum change that takes place in higher education institutions (HEIs).

[15] In this study medium N refers to 230 case studies.

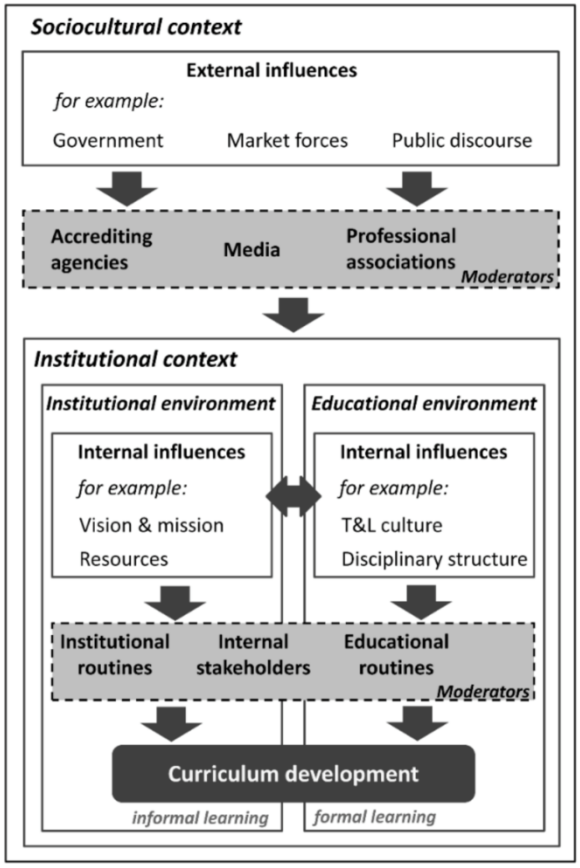


Figure 3.3 Layers and moderators of curriculum development (Barth, 2015)

Curriculum change related to sustainability is embedded in a variety of processes with internal and external influences. As sustainability curricula are realized internally through many processes within an HEI, a brief overview of the main internal influences is provided below, and external influences are discussed subsequently.

First, two general influences can be distinguished internally: the *institutional environment* and the *educational environment*. Both influences have a direct impact on curriculum development through specific routines and stakeholders. In the institutional environment, for example, factors such as the vision of the university, strategic planning, resources, support mechanisms, campus sustainability, collaboration, and communication play a role. In the educational environment, for instance, the teaching- and learning (T&L) culture, the respective disciplines, and the degree of interdisciplinarity shape the curriculum topics and their development. Internally, stakeholders (leadership, lecturers, students) – who have different opinions, emotions, attitudes (e.g., toward sustainable development or change), interests in sustainability topics, and knowledge and resources needed to teach education for sustainable development (ESD) – are crucial in establishing sustainability courses at an HEI.

External factors and stakeholders (sociocultural context), in turn, affect internal processes. For example, governmental restrictions (e.g., laws or public funding) specify the extent to which ESD should be implemented or what curriculum changes are possible. Companies and other employers

demand certain competencies and skills from graduates and thus put pressure on universities to develop the employability of their students. Public discourse keeps certain topics relevant (e.g., climate change) and highlights the societal responsibility of HEIs to implement ESD by raising awareness about sustainability challenges. Various stakeholders – such as accreditation agencies (which are decisive in establishing new programs), professional associations (which dictate certain topics and/or skills), and the media (which mediates public discourse) – act as moderators for external concerns and demands.

3.2.2 Patterns of Sustainability Curricula Change

To date, little research has been conducted on specific patterns of different implementation processes for curricula relating to sustainability. Single case studies have illustrated how implementation can be successful, but it often remains unclear which interactions between different drivers and barriers – and in which contexts certain factors – have a decisive effect on permanent implementation. The implementation process is often seen as being individual because higher education institutions (HEIs) differ, for example, in context, size, history, mission, and country. However, the worldwide implementation of sustainability curricula could be advanced if HEIs were better able to learn from one another's processes.

Only a few studies have thus far focused on specific implementation patterns concerning sustainability curricula. In a study of eight German HEIs, Barth (2013) found three distinctive implementation patterns of sustainability curricula: (1) a student-led change from informal to formal learning, (2) sustainability as a concern in campus operations, and (3) sustainability as a unique selling point.

Ferrer-Balas et al. (2008) analyzed seven international cases using a framework–level–actor approach but could not find shared patterns across cases. Furthermore, various authors have provided guidelines for implementing successful change processes based on small-N case studies (Junyent & Geli de Ciurana, 2008; Velazquez et al., 2006) and have assumed that their experiences can be applied to other HEIs.

Therefore, a meta-study that compares a larger number of cases is needed in order to better understand how implementation processes take place. It has been more than 15 years since Corcoran et al. (2004) asked whether certain patterns of implementation processes exist. An analysis of a greater N of case studies has thus far been hindered by the lack of a database of case studies, a missing analytical scheme, and the vast effort required to analyze several hundred cases.

This research gap led to the third gap addressed in this thesis:

→ Gap 3: More theory building that takes into account robust data from a medium N of case studies (i.e., a meta-study) is needed on the *interaction* between various drivers of and barriers to sustainability curriculum implementation patterns that are shared in different contexts.

3.2.3 Level of Depth of Sustainability Curricula Change

Since this dissertation investigates what factors are drivers of or barriers to the implementation of sustainability curricula and what patterns of influencing factors lead to which level of higher education for sustainable development (HESD) implementation, it is useful to conceptualize how the level of implementation can be determined. In making this determination, attention should be paid to a dimension introduced at the beginning of this section: the "level of depth of sustainability curriculum change processes" (see Section 3.2). In Study 2 (see Section 5.3), various conceptualizations are considered when determining how to examine the level of sustainability curriculum change, and focus is placed on a concept suggested by Sterling and Thomas (2006) that is linked to progressive levels of learning (as described in Section 3.1). Since this concept serves as the basis for the overall study design of the present dissertation (i.e., particularly for Studies 2 and 3 and therefore also for the coding scheme), the used concept is briefly introduced at this point. Additional details can be found in Study 2 (see Section 5.3).

Based on earlier work by Sterling (2001), Sterling and Thomas (2006) suggest distinguishing between different types of education for sustainable development (ESD) – depending on the pedagogical and didactic approach – along a continuum ranging from emancipatory and transformative to instrumental and simplistic approaches, or from first-order- to third-order learning (depending on the type of reflection by the learner or institution) (for more information on different levels of reflection, see Section 3.1). Relating to these conceptualizations, the authors distinguish between four types of ESD: no change, education about sustainability, education for sustainability, and education as sustainability (as explained earlier in Section 3.1). Sterling and Thomas (2006) link these levels to the different approaches used by universities for implementing ESD, and they draw a continuum between holistic change and paradigm shift vs. minimal effort from the institution (for more details, see Table 3.1). Again, the authors distinguish between four levels: *denial* (the university does not respond to the need to implement ESD), *bolt-on* (the university adds some sustainable topics to existing courses but does not reflect on underlying mindsets), *build-in* (the university introduces significant changes regarding ESD: sustainability finds its way into (new) interdisciplinary courses, prevailing paradigms are reflected upon, and initial attempts are made to integrate sustainability into other areas of the higher education institution), and finally, *redesign* (the university responds holistically, a paradigm shift takes place, prevailing thought patterns are reflected upon, and sustainability is established and connected through teaching, research, campus, and outreach; some scholars refer to *redesign* as a "whole-institution approach" because sustainability is introduced into all areas of the institution) (Mcmillin & Dyball, 2009; Schopp et al., 2020; TESF, 2020; UNESCO, 2020).

In the present study the trend toward a redesign change is described by referring to more comprehensive or deeply rooted sustainability curriculum implementation.

Table 3.1 Levels of sustainability curriculum implementation in higher education institutions (HEI) and their educational responses to sustainability; ESD refers to education for sustainable development (author's own elaboration based on the work of Sterling (2001) and Sterling and Thomas (2006))

Level	HEI response	Type of ESD	Description	Pedagogical Approach
high / very strong	redesign	education *as* sustainability	-holistic change and paradigm shift that places sustainability principles, ethics, and values at the core of the curriculum and requires the engagement of the entire person and institution -ESD is integrated into the common core requirements and/or the vision of the HEI	emancipatory & transformative (third-order learning)
middle / strong	"build-in"	education *for* sustainability	-significant changes to the curriculum are made by including coherent coverage of content, values, and skills associated with sustainable development and a critical questioning of assumptions -sustainability is addressed in (interdisciplinary) programs / courses that focus on integrating sustainability issues -first linkages of ESD modules with other HEI areas, such as operations / campus	
low / weak	"bolt-on"	education *about* sustainability	-leaves current paradigm change unchallenged -sustainability concepts are added to specific existing disciplinary courses or programs (content based sustainability literacy) -minimal effort from the institution	instrumental & simplistic (first-order learning)
very weak	denial	no change	/	

Part II

Research Design

4 Research design

4.1 Research Gaps and Research Questions

As shown in Chapter 3, specific gaps have hindered the ability to gain a better understanding of sustainability curriculum implementation processes in higher education institutions. As the discourse is mainly characterized by a scattered body of single case studies, generalizable findings on a larger scale are missing. The following research gaps are apparent:

Gap 1: A global and systematic overview of the differentiated and fragmented field of (mainly individual) case studies is missing that would enable reflection on both the research field and sustainability curriculum implementation processes across different contexts.

Gap 2: Empirical evidence – based on a medium N of case studies (meta-study) – of key drivers and barriers across different contexts is missing.

Gap 3: More theory building that takes into account robust data from a medium N of case studies (i.e., a meta-study) is needed on the *interaction* between various drivers of and barriers to sustainability curriculum implementation patterns that are shared in different contexts.

To tackle these research gaps, the following overarching research inquiry and sub-questions are investigated:

Overarching research inquiry: What generalizable drivers and barriers influence more comprehensive sustainability curriculum change in higher education institutions, and how could a better understanding of specific implementation patterns enable sustainability curriculum change in higher education institutions?

> **Research Question 1:** What is the current research landscape of case studies on sustainability curriculum implementation processes in higher education institutions? (Gap 1)
>
> **Research Question 2:** What key drivers and barriers influence the implementation processes of sustainability curricula in higher education institutions? (Gap 2)
>
> **Research Question 3:** What distinctive patterns of sustainability curriculum implementation processes exist in higher education institutions? (Gap 3)

4.2 Case Survey Method as a Methodological Approach

As described in Section 3.2, the discourse is dominated by single case studies that offer rich qualitative insights into sustainability curriculum change processes in specific HEIs. These deep, context-specific insights are useful but leave unclear the extent to which insights can be applied to other cases and be generalized. It is thus necessary to compare the individual case studies systematically to detect patterns that are shared across them.

In order to compare a large number of case studies, meta-analyses are useful. Newig and Fritsch (2009) offer a comparison of different types of meta-analyses based on the type of data (quantitative / qualitative) and the integration method (quantitative / qualitative) (for a more-detailed discussion of various approaches used to synthesize case studies, see Weiss & Barth, 2020c, which can also be found in Appendix No.5, Section 10.5.).

For comparing *qualitative* case studies, the *case survey method* (Lucas, 1974; Newig & Fritsch, 2009; Yin & Heald, 1975) "[…] is particularly suitable when case studies dominate an area of research (Yin & Heald, 1975), when the unit of analysis is the organization, [or] when a broad range of conditions is of interest (Jauch et al., 1980) […]" (Larsson, 1993, p. 1992). In certain contexts, the case survey method is also referred to as a *case meta-analysis* (Bullock & Tubbs, 1987), a *meta-analysis* (Jensen & Rodgers, 2001; Rodgers & Hunter, 1992), or a *structured content analysis of cases* (Jauch et al., 1980).

The case survey method is unique in that it allows a large number of qualitative case studies to be transformed into a database of quantitative data in a highly structured way in order to enable new results to be obtained through various statistical analyses. One great advantage of the case survey method is thus that the findings of individual case studies – which result from different perspectives, foci, and methods – can be integrated. This integration is enabled via a systematic and structured approach with a sophisticated coding scheme at its core for converting qualitative data into quantitative data. Such an approach enables a more-integrative interpretation of findings that goes beyond the individual findings of the case studies and thereby enables researchers "to systematically and rigorously synthesize previous case-based research by drawing on the richness of the case material, on different researchers and research designs, and at the same time allowing for a much wider generalization than from single cases" (Newig & Fritsch, 2009, p. 1). This generalization for larger populations – as well as the opportunity to detect patterns that are shared across case-specific contexts – is one of the case survey method's great advantages (Lucas, 1974). Larsson (1993) further highlights that case surveys offer a bridge as they can be used to "[…] overcome the problem of generalizing from a single case study and at the same time [enable] more-in-depth analysis of complex organizational phenomena than questionnaire surveys" (Larsson, 1993, p. 1516).

Disadvantages of the case survey method include the large number of primary studies that are relevant to the research question, the volume and quality of the data (due, for example, to space limitations), and the challenge of keeping the balance between the loss of case-specific rich descriptions of data vs. generalizability (however, a good coding scheme can minimize information loss) (Larsson, 1993).

A further challenge for the present study lies in applying the case survey method to the field of ESD as there is limited to no precedent in other studies.

Newig and Fritsch (2009) briefly outlined the development and application of the case survey method in other fields. The case survey method was developed in the 1980s and – surprisingly – has generally been used rather little in other disciplines to date (Newig & Fritsch, 2009, p. 7). In the sustainability sciences, for example, the method is used primarily in the area of governance (Newig et al., 2019). A

brief search for the application of the case survey method in educational science revealed that only a few studies have thus far used the method in this field (Berger, 1983; Morgan, 1981).

In order to apply the case survey method, slightly different approaches have been proposed by different researchers. The present research is based on the steps recommended by Newig and Fritsch (2009), which draw largely on the contributions by Bullock and Tubbs (1987) and Larsson (1993). Figure 4.1 presents an overview and the sequence of the various steps that were carried out in the present work.

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 dataset (statistical or otherwise).
12. Report the study.

Figure 4.1 Case survey method steps (adapted from Newig & Fritsch, 2009)

4.3 Overview of Connected Studies & the Application of the Case Survey Steps

To address the overarching research interest of this thesis, the different studies (Research Articles 1–3, Chapter 5) all draw on the case survey method (see Figure 4.2). Research Article 1 (Section 5.2) thereby builds the foundation because the first step was to understand the research landscape. In concrete terms, this means that the isolated and scattered case studies on sustainability curriculum implementation processes in HEIs had to be collected, summarized in a case universe, and – most importantly – analyzed bibliographically. The other two research articles build upon this case universe by investigating two lines of analysis: On the one hand, in Research Article 2, a quantitative analysis was performed to determine which key drivers and barriers are mentioned in the individual studies and whether they correspond to theoretical assumptions (Section 5.3). On the other hand, in Research Article 3, the different implementation patterns serve as the focus of the analysis. A cluster analysis (Backhaus et al., 2016) was used to analyze which variants of influencing variables occur

together and to determine the extent to which these variables have led to varying degrees of sustainability curriculum embeddedness throughout HEIs (Section 5.4).

Figure 4.2 Overview of the three articles and their contribution to the research questions; HESD refers to higher education for sustainable development (author's own elaboration)

In the following section, the individual steps of the case survey method (see Figure 4.1) are explained in detail. The methodical explanation comes first, followed by the practical implementation used in the present study.

Steps 1–2: Develop research questions & decide on a methodology

The formulation of one or more hypotheses or exploratory questions lays the foundation for the structured synthesis, aggregation, and integration of knowledge from the case studies. After formulating the research questions (see Section 4.1), it is necessary to decide whether the case survey method is appropriate and how it will be carried out in detail. Consideration should be given to the availability of the data / case studies, their quality, whether additional material or the authors of the case studies can be consulted, and the level of detail with which the case studies will be examined. Furthermore, it is necessary to plan how many raters will be used. At this point, the entire process – including time and resources – is planned (Newig & Fritsch, 2009).

The research questions of the present study are described in Section 4.1. As the greatest knowledge about sustainability curriculum implementation processes comes from case studies, the case survey

method is highly appropriate as advised by Newig and Fritsch (2009). The following steps describe the implementation used in the present study in greater detail.

Steps 3–4: Define case-selection criteria & collect a case sample universe

In order to determine the generalizability of the findings, it is important to define the population- or case universe. Depending on interest in the findings, control groups may also need to be considered. It is also recommended that the universe of cases not be restricted by quality (publication status, methodological rigor) as such a restriction could introduce biases. In general, all assumptions regarding possible biases should be transformed into variables in order to render them controllable (Newig & Fritsch, 2009). Newig and Fritsch (2009) further advise that "[i]n terms of [the] thematic scope of the study, it seems useful to define the universe of cases quite tightly and study a significant sample of it rather than defining a broad universe and studying a comparatively small sample of it" (p. 9). Since the case survey is a meta-analytical technique used to compare cases, the case is the unit of analysis. Therefore, one or more publications – or even part of a publication (small-N comparative case studies) – can provide information for one case (Newig & Fritsch, 2009).

To produce a representative sample of case studies that is consistent with the definition of the case universe, as many case studies as possible need to be collected from as many sources as possible. From this set, all case studies – or a random set of case studies – can be analyzed. Poor data quality would be a sufficient reason to exclude case studies that have already been collected (Newig & Fritsch, 2009).

As the research interest of the present study lies in sustainability curriculum implementation processes in higher education institutions worldwide, the unit of analysis is the higher education institution and its sustainability curriculum implementation process. The universe of cases consists of 230 sustainability curriculum implementation processes in higher education institutions from around the globe.

To identify case studies and collect the case universe, specific case-selection criteria were defined (Step 3):

- The overall topic had to be on higher education for sustainable development (HESD),
- at least one specific case (higher education institution) had to be mentioned,
- the focus of the publication(s) had to be on reporting, analyzing, or discussing a case-specific sustainability curriculum implementation process, and
- the articles and reviews had to have been published in English between 1990 and 2017 in peer-reviewed volumes.

Based on the research inquiry, the focus lay on the concept of *sustainability education* and not on environmental education or other concepts. The timeframe (1990–2017) coincides with the dawn of publishing about such processes. Only peer-reviewed case studies in English were used to identify cases.

In order to perform a structured collection of data, a comprehensive search strategy with various steps was utilized (see Figure 4.3):

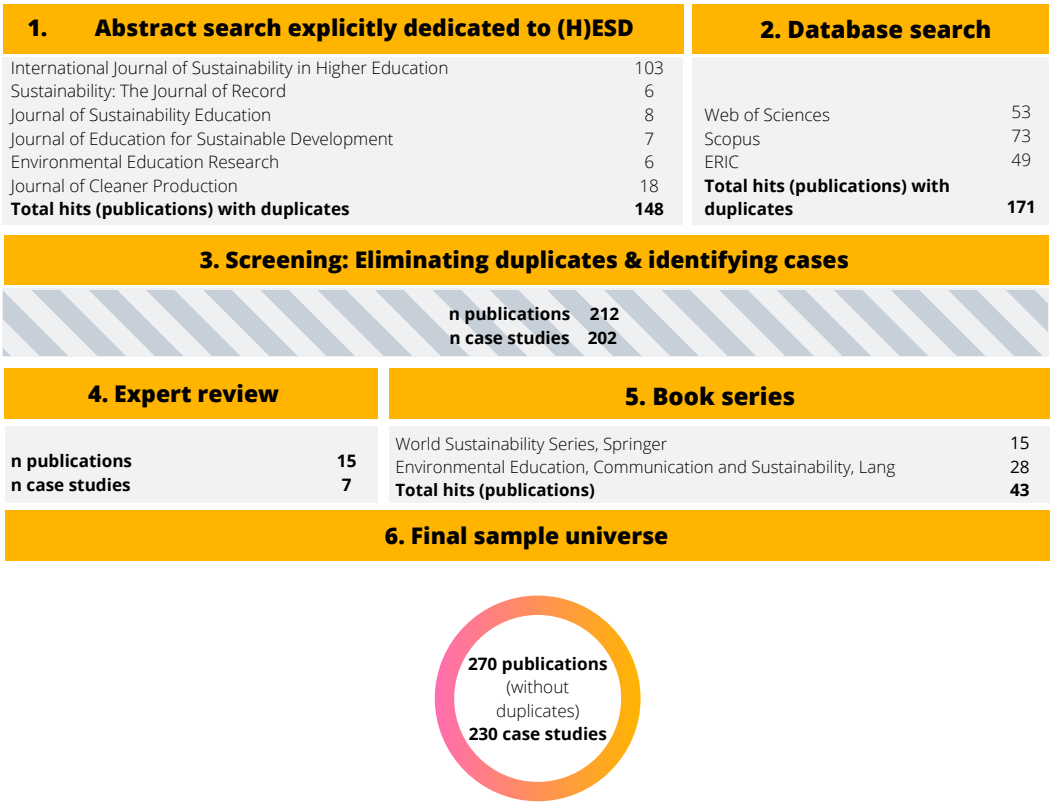


Figure 4.3 Structured collection of data (Case Survey Method Step 4) (H)ESD refers to (higher) education for sustainable development (author's own elaboration) (author's own elaboration)

(1) In the first step, selected journals dedicated to (higher) education for sustainable development were reviewed. The journal selection was based on previous research (Barth and Michelsen, 2013; Barth and Rieckmann, 2016) and covered highly relevant journals in the field. Relevant articles were identified by first reviewing the tables of contents of the journals. For two of the journals, a search string was used instead due to the large number of articles (details are explained in Research Article 1, Section 5.2). In the second step, all selected articles were reviewed and selected based on their abstract.

(2) Second, supplementary search queries were made in three bibliographic databases: Scopus, the Web of Science, and the Education Resources Information Center (ERIC). Scopus and the Web of Science were selected as they are the two largest databases that represent the social sciences and the sustainability sciences, respectively, and ERIC was chosen as it covers research collections in educational science. The following search string was applied in all three databases with a few adjustments depending on the different functions: TITLE-ABS-KEY (("higher education" OR universit* OR college OR "tertiary education" OR "post-secondary education" OR facult*) AND (curricul* OR course OR program OR degree) AND

("education for sustainable development" OR "education for sustainability" OR "sustainability education")).

(3) In the final step, the sample universe was reviewed and complemented in two ways: First, an expert review was carried out by ten experts in the field of HESD from around the globe who were asked to identify missing cases and publications. Second, in order to add supplementary data published in offline media, relevant edited volumes were researched via reviews of tables of contents and abstracts. The final sample universe amounted to 270 publications without duplicates and included 230 case studies.

A database of all publications was created that included bibliographic data, the abstract, and the full text. The sample of publications was identified by a trained team consisting of three student assistants and the author. All cases that were identified as relevant were double-checked by the author.

To handle the large volume of data, the case studies were structured in two steps: First, they were distinguished based on their general level of information. This distinction was made using the categories of *Relevance 1* and *Relevance 2*.

- *Relevance 1:* Case studies with at least one publication that focus on the sustainability curriculum implementation process. These studies could be single or comparative case studies.
- *Relevance 2:* Case studies that only marginally describe the sustainability curriculum implementation process. These studies could be single or comparative case studies.

To further cope with the volume of data and the available resources, *Relevance 1* cases were distinguished based on the type of publication due to the assumption that single peer-reviewed case studies offer the most-comprehensive analytical data (i.e., the highest data quality). Therefore, the following categories were created:

- *Long:* Case studies that are described in depth in at least one peer-reviewed journal article and in at least one additional publication, which could include book chapters, comparative case studies, and *Relevance 2* publications.
- *Short:* Case studies that are described in depth in only one peer-reviewed journal article (single case study) but in no additional publications.
- *Book chapter:* Case studies that are described in depth in at least one book chapter; additional publications could include *Relevance 2* peer-reviewed articles.
- *Comparative:* Case studies that are included in at least one comparative study; additional publications could include *Relevance 2* publications.

An overview of the various categories and their frequency distribution is shown in Figure 4.4. Of the 230 case studies, 10 were excluded because the topic of interest was not part of the published full text or because the relevant higher education institution no longer existed in the same form.

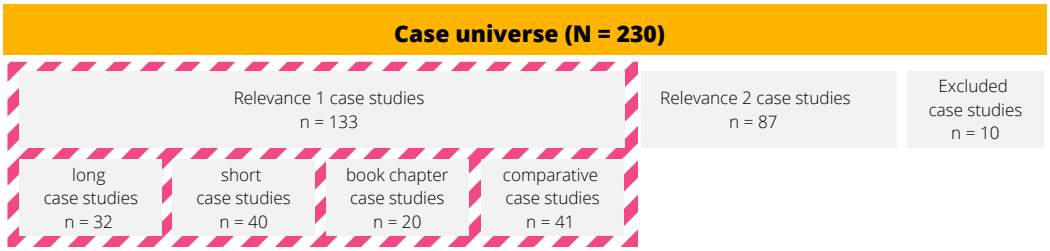


Figure 4.4 Structure of the case-study universe (author's own elaboration)

A short list with the name of the HEI, country, and continent of each case study can be found in Appendix No. 2, Section 10.2. The comprehensive database (including all 230 collected case studies ordered based on their relevance, the type of publication, the name of the HEI, country, continent, and publications) can be found in an open-access Excel file on ResearchGate (Weiss & Barth, 2020b).

During the coding process, all 133 Relevance 1 case studies were analyzed, and the already-identified case material was complemented with up-to-date information from the respective HEI websites for some of the variables (for details, see Appendix No. 5, Section 10.5.).

Steps 5–6: Design an initial coding scheme & pre-test and create an iterative revision of the coding scheme

In order to systematically synthesize data from a qualitative case study based on a research inquiry, a coding scheme needs to be developed. This analytical scheme must contain a number of variables with which the questions can be analyzed and that are precisely defined and operationalized (qualitative data must be converted into quantitative codes). Furthermore, rules for certain coding decisions must be defined. Variables can be deductive or inductive. Throughout the entire coding process, the coding scheme forms the core of the case survey method and must be developed carefully (Newig & Fritsch, 2009). Newig and Fritsch (2009) further recommend developing an extensive coding scheme because at a later point, it is possible to aggregate data and variables, but not vice versa. The authors also point out that the effort needed to code several variables is not much greater than that needed to search for, read, and analyze the case studies with a minimalistic coding scheme. Newig and Fritsch (2009) also indicate that the reliability of each individual code can be recorded to analyze subsets later.

After developing a first draft of the coding scheme that takes the aforementioned considerations into account, a pre-test with an iterative revision of the coding scheme needs to be performed (Newig & Fritsch, 2009). The coding scheme must therefore be applied to a small number of cases by at least two different raters independently, which enables a determination as to whether (1) the coding scheme is comprehensible, (2) the variables can be understood and used by different people in the same way, (3) the coding rules are clear or missing, and (4) all important information is covered or new inductive variables need to be added. Furthermore, the raters can practice and discuss handling complex and ambiguous coding decisions. If a high inter-rater reliability has been achieved and all

ambiguities regarding the coding scheme have been resolved, the scheme can be finalized (Newig & Fritsch, 2009).

The proposed analytical scheme for the present study aims to capture the available information on a deep and detailed level. For this purpose, 111 standardized variables with detailed operationalization were developed. This method was a first attempt at creating a rigorous procedure for comparing a large number of sustainability curriculum implementation processes in higher education. The coding scheme was based on existing research. As a starting point, the logic model of drivers and barriers – compiled and structured by Barth (2015, ch. 11) (see Figure 3.3) – served as a basis. Additionally, a broad literature review was undertaken to detect missing variables or an existing operationalization of variables. Most of the variables were mentioned in several sources. New variables or details about the variables were filtered out and incorporated into the coding scheme, especially from the following sources: Banga Chhokar, 2010; Barth, 2013; Ferrer-Balas et al., 2008; Hurney et al., 2016; Junyent & Geli de Ciurana, 2008; Kitamura & Hoshii, 2010; Lidgren et al., 2006; Muhar et al., 2013; Thomas & Nicita, 2002; Velazquez et al., 2005. In this way, the final operationalization was informed by prior research, but in order to be made applicable to the present research focus, a new operationalization needed to be developed for all variables.

To test the coding scheme, in the first step, three raters independently checked the comprehensibility of the variables. Afterward, all ambiguities regarding variables, definitions, and coding rules as well as suggestions for possible changes were discussed and resolved in a workshop. In a further step, five pilot cases were independently coded by four raters. After each finalized coded case, the codings of all five raters (three trained student assistants, one research assistant and the author) were compared in order to increase the comprehensibility of the variables. This process was repeated until the 5th case had been found to have a high inter-rater reliability. During this process, the coding scheme was adapted and complemented with inductive variables drawn from the case-study material. It was intended to be applicable to all higher education institutions, regardless of socio-cultural context.

In general, the coding scheme enabled the analysis of three main items: (a) the description of the higher education institution, (b) the level of the sustainability curriculum change process, and (c) the underlying mechanisms along with their various drivers and barriers. To further structure these main items, the variables were organized into nine overarching categories:

1. Basic data case
2. Basic data HEI (higher education institution)
3. Educational environment
4. Implementation process
5. Leadership
6. Support during the sustainability curricula implementation process
7. Internal stakeholders
8. Sociocultural context
9. Level of sustainability curricula implementation

Detailed descriptions of each variable and an overview of where they can be found in the logic model of drivers and barriers created by Barth (2015) can be found in Weiss and Barth (2020c) (Appendix No.5, Section 10.5).

General operationalization of variables

The variables that describe the underlying processes were predominantly classified as (a) barrier (lack of / weak), (b) medium (described, but with unclear / ambivalent impact), (c) driver (high / strong), (d) other (if no category matched the description), or (e) not described (missing information).

The central variable used to describe the achieved level of the sustainability curriculum implementation process is "sustainability curricula implementation," for which the approach of Sterling and Thomas (2006) was used: The level and the depth of the curriculum change were classified into the categories of *denial* (no change), "*bolt-on*" (education about sustainability), "*build-in*" (education for sustainability), or *redesign* (sustainability education).

Steps 7–9: Create a final coding of cases via multiple raters, measure inter-rater reliability, & resolve important coding discrepancies

The final coding certainly requires the most time and personnel resources. Various scientists recommend having each case coded by at least 2–3 raters (Newig & Fritsch, 2009). Furthermore, Newig and Fritsch (2009) advise excluding pilot cases from the final dataset in order to avoid introducing bias in terms of a learning effect. Additionally, inter-rater reliability should be measured. Building on Bullock and Tubbs (1987), Larsson (1993, 1533f.) recommends using percent absolute agreement, especially for categorical variables. In order to resolve discrepant codes, the most-recommend method – especially for categorical variables – is consensus rating (Larsson, 1993).

The coding scheme of the present study was applied to all *Relevance 1* case studies (n = 133). To code cases with multiple raters, an interplay between several tools was designed that consisted of reference-management software on a shared server, a database that used Google Sheets to transform the (mostly qualitative) data into quantitative data, and supplementary factsheets that provided in-depth qualitative data and a coding protocol for each case (an example of a factsheet can be found in the EFCA analytical scheme, Appendix No. 5, Section 10.5). In order to make the coding even more transparent, MAXQDA software was used and yielded data points for the respective coded variables. For some variables (e.g., current vision), additional data were collected using the respective HEI's website and annual reports. Coding was conducted by five trained raters with an inter-rater agreement of 94% (tested for 10% of cases). Discrepancies were resolved using the consensus approach. According to several scholars, a two-thirds agreement is viewed as satisfactory reliability (Larsson, 1993). Due to limited resources, it was not possible for all 133 cases to be coded by more than one rater. In order to use as many case studies as possible, the pilot cases were added to the final sample because coding discrepancies had been resolved by consensus, and these cases were revised after completing the test phase.

Step 10: Analyze biases statistically

It is important to consider which possible biases may be inherent in a case universe and dataset. Described biases are often introduced by the selection of the case studies, the type of publication, or time. Some scholars suggest using reliability coding (Newig & Fritsch, 2009).

After the pilot phase, during which the coding scheme was tested, it was deemed unnecessary for extra variables to capture the reliability of each coding decision since the level of confidence for coding the variables did not vary much or the coding was solved via consensus rating. Yin and Heald (1975) explain that a good level of confidence (or, as they put it, "a sure response") is reached if the coder can cite the specific phrase that contained the answer. In the present study, this was ensured by using a coding protocol with justifications for each coding as well as MAXQDA files for capturing the specific text phrase(s) for each variable / coding.

Furthermore, in the present study, no systematic influence of time, the type of publication, country, continent, or coder could be found. Possible biases regarding the selection of the case studies are thoroughly discussed throughout the study.

Step 11: Analyze the created case dataset

A variety of statistical and complementary non-statistical methods may be used to investigate a research inquiry. Common methods include bivariate correlations, regression analysis, and cluster analysis (Newig & Fritsch, 2009).

The present dataset was analyzed by various methods according to the specific research questions. In Research Article 1 (Section 5.2), frequency analyses using R and Tableau were conducted, and additional bibliometric analyses using R and VosViewer added to the findings. In Research Article 2 (Section 5.3), a frequency analysis and chi-square tests were performed using R to investigate key drivers and barriers. In Research Article 3 (Section 5.4), triangulated data – which were investigated via a cluster analysis conducted in R and via descriptive data from the factsheets – were used to identify and describe specific implementation-process patterns. Table 5.1 in Section 5.1 provides a comparative overview of the various methods that were applied in conjunction with the respective research questions. Details are further elaborated in the respective research articles.

Step 12: Report the study

As a case survey yields a large volume of data through a highly structured approach, it is useful to publish all documents that support the transparency of the process (Newig & Fritsch, 2009). Larsson (1993) advises that these documents contain the list of included and excluded cases, the coding scheme, and the frequency, mean, and standard deviation of all variables.

The present study reports all results via three journal articles. Various presentations on the results have also been given at HESD conferences. Additionally, further publications are openly available: (a) a list of the case universe with Relevance 1 (included) and Relevance 2 (excluded) cases, including the respective publications; (b) a descriptive statistical report of all variables; and (c) the coding scheme with detailed definitions and an operationalization of all variables. Since each study was based on a

slightly different case sample, a description of each case sample can be found in each respective research article.

Part III

Results

5 Individual Studies & Results

5.1 Overview of the Three Articles and their Contributions to the Research Questions

The results of the three individual research articles are presented below. Since this is a cumulative dissertation, each of the three articles comprises a main sub-chapter in this Results section. In order to more-easily relate the individual results of the sub-chapters to one another and to the research questions, a rough overview was presented in Figure 4.2 that is complemented by Table 5.1 with the goal of providing an overview and a comparison of the articles, including their key findings, limitations, and contributions. More details can be found in the respective Results chapters of the three research articles. In the subsequent Synthesis chapter, the results of the individual articles are summarized, supplemented with additional data, and compared with one another.

Table 5.1 Overview and comparison of Studies (Research Papers) 1, 2, & 3

	Paper 1: The Global Research Landscape of Sustainability curricula implementation in Higher Education	**Paper 2:** Drivers and Barriers of Implementing Sustainability Curricula in Higher Education – Assumptions and Evidence	**Paper 3:** The Patterns of Curriculum Change Processes that Embed Sustainability in Higher Education Institutions
What is already known about the topic?	– A growing body of work exists on curriculum change processes in HESD, with case-study research playing a prominent role (the focus lies on a few HEIs in one or various countries).	– Theoretical assumptions exist about drivers and barriers, with the (mostly descriptive) evidence coming from single or small-N (comparative) case studies.	– Little knowledge has been gained on the relationship between influencing factors and specific HESD implementation patterns.
Research gap(s)	– The field of (mainly individual) case studies is differentiated and fragmented, which makes it difficult to draw generalizable conclusions and understand patterns. – A global and systematic overview is missing.	– Empirical evidence (which is based on a large number of case studies and is therefore more generalizable) is missing on key drivers and barriers and their connections with the level of sustainability curriculum implementation.	– More theory building is needed that takes into account the interaction between various drivers and barriers while searching for implementation patterns that are shared in different contexts.
Research question(s)	– What is the current research landscape of case studies on sustainability curriculum implementation processes in HEIs?	– What key drivers and barriers influence the implementation processes of sustainability curricula in HEIs?	– What distinctive patterns of the implementation processes of sustainability curricula exist in HEIs?
Methodological approach	– A systematic review (one step of the case survey method) of peer-reviewed case studies published in English in selected journals and edited volumes between 1990 and 2017 is provided (N =230 case studies, N = 270 publications). – Descriptive statistics and bibliometric analysis are conducted in Tableau, R, and VosViewer.	– A review of pertinent assumptions in the literature is provided. – The case survey method (n = 133 case studies) is used to synthesize the most-common drivers and barriers. – Assumptions are tested via frequency analysis and chi-square tests.	– The case survey method (n = 131 case studies) is used to derive consolidated knowledge on different patterns of implementation processes through a cluster analysis (with a focus on the interrelationships between influencing factors and the achieved level of sustainability curriculum implementation).
Key findings	– A growing output exists from a broad range of journals. – The cross-country distribution is imbalanced, with most cases coming from the USA, Europe, and Asia, but with the highest relative density in Oceania. – The "Western world" is quite well connected, whereas other countries are not, which indicates that sharing information between and learning from cases is limited.	– Hypothesis test: Drivers that lead to more comprehensive implementation include strong leadership; incentives and support through professional development; the concurrent implementation of sustainability in research, campus operations, and outreach; and the formal involvement of internal and external stakeholders as well as of sustainability champions. – Frequency test: Additional drivers include strategic planning, coordination, communication, vision, government influence, the presence of a window of opportunity, and interdisciplinary spaces. Common barriers include the lack of interdisciplinary spaces, a vision, incentives, resources, or space in the curriculum as well as a weak organizational structure.	– 6 specific patterns of sustainability curriculum implementation processes are identified: 1. Collaborative paradigm change (redesign level) 2. Bottom-up, evolving institutional change (redesign- / build-in level) 3. Top-down, evolving institutional change (build-in- / redesign level) 4. The presence of many barriers that hinder institutional change (bolt-on) 5. Externally driven initiatives (build-in & bolt-on) 6. Scattered initiatives due to lacking coordination (build-in & bolt-on)

	Paper 1: Global research landscape of sustainability curricula implementation in higher education	**Paper 2:** Drivers and Barriers of Implementing Sustainability Curricula in Higher Education – Assumptions and Evidence	**Paper 3:** The patterns of curriculum change processes that embed sustainability in higher education institutions
Discussion & Limitations	– The exclusion of non-English publications likely skewed the global distribution of the research landscape. – The number of cases reveals where research has been performed and not necessarily where students can study sustainability topics.	– The case sample was imbalanced in terms of countries. – There was a bias toward success stories (as most are self-reported). – Cases were treated as secondary data (i.e., they varied in terms of focus, perspectives, methodology, and missing data). – Missing information was considered irrelevant. – Only a snapshot of the process was gained. – The analyzed case studies vary widely in their depth and usage of empirical material, which indicates a need for common research protocols in order to enable cross-case comparisons.	– *The limitations mentioned for Paper 2 also apply here.* – Clusters 4 and 5 include a comparative case study that comprises a large part of the cases in these clusters. For these clusters, a broader database would be desirable in order to confirm the strands of implementation processes identified within these clusters.
Conclusion	– More research and funding are needed for case studies in countries that have not yet been adequately examined. – Concepts other than SD and the type of publication need to be included.	– HEIs can utilize the findings to recalibrate their implementation processes by focusing on the most-pertinent drivers and barriers. – While the meta-study yielded and confirmed a number of drivers and barriers that influence sustainability curriculum implementation in HEIs, gaps in data availability and other issues limit the generalizability of the findings. – A standardized protocol is needed for case studies that can support future research and information exchange on implementation processes.	– As qualitative data availability is critical in further investigating patterns, future researchers should focus on single or comparative case studies and keep an eye on the complexity of the change while being more explicit with (a) the various factors that influence and do not influence implementation, (b) the different phases of the process, (c) the achieved change, (d) the relationships between factors.
Contribution	– This study offers the first systematic reflection on the current global research landscape of sustainability curriculum implementation in terms of the cross-country distribution and the general development trend (i.e., the bibliographic analysis) of the research field and can serve as a foundation for further research endeavors.	– This study offers insights into drivers and barriers beyond single case studies via a meta-study of 133 case studies by (a) synthesizing the most-common barriers and drivers from single cases and deriving a top-ten list, (b) testing dominant assumptions by linking drivers and barriers to sustainability curriculum implementation levels, and c) identifying information gaps. – The results of this study provide a response to the growing interest in initializing, adopting, and adding sustainability curricula.	– This analytical meta-study and cluster analysis of 131 case studies reveals generalizable insights into specific patterns of sustainability curriculum implementation processes in different contexts. – Successful implementation strategies can be derived that can inform evidence-based recommendations for HEIs worldwide.

Note: The text in the table draws heavily from the various articles.

5.2 Study/Article 1: Global Research Landscape of Sustainability curricula implementation in Higher Education

Marie Weiss, Matthias Barth

5.2.1 Abstract

Purpose – This paper aims to outline the global research landscape of sustainability curricula implementation processes in higher education. The focus is twofold and investigates where research that aims at integrating sustainability into the curriculum is happening and how the research area of curriculum change for sustainability is developing.

Design/methodology/approach – A systematic review of peer-reviewed case studies published in English in selected journals and edited volumes between 1990 and 2017 was carried out. Data (n = 270 publications) were analyzed via descriptive statistics and bibliometric analysis.

Findings – The study demonstrates that research on sustainability curricula implementation processes in higher education has produced a growing output in a broad range of journals. Nevertheless, the cross-country distribution is imbalanced, with most cases coming from the USA, Europe and Asia, but with the relatively highest density in Oceania. A citation network analysis revealed that the "Western world" is quite well interlinked, whereas other countries are not, indicating that sharing information between and learning from other cases is limited.

Research limitations/implications – The exclusion of non-English publications likely skewed the global distribution of the research landscape included in this study.

Social implications – These findings demonstrate the need for more research and funding for case studies in countries that have not yet been adequately examined.

Originality/value – This study offers the first systematic reflection on the current global research landscape in sustainability curricula implementation and can guide further research endeavors.

Keywords Sustainability, Universities, Education for sustainable development, Higher education, Systematic review, Curriculum change

Paper type Research paper

5.2.2 Introduction

While the implementation of sustainable development as a societal vision should be supported in all educational sectors, it is higher education that has a particularly key role to play in the overall process of striving for sustainable development. Universities not only generate and transfer relevant knowledge but also enable future change agents to contribute to a sustainable future (Barth, 2015; Lotz-Sisitka et al., 2015). Accordingly, the "International Association of Universities" highlights the notion that:

> *"Leaders of higher education institutions and their academic colleagues are in a key position to contribute to an equitable and ecologically sound future by making sustainable development a central academic and organisational focus. [. . .] It is critical that higher education institutions understand and accept their responsibility within the broader context of social and economic development, and the building of democratic, equitable and ecologically-minded societies." (IAU, 2010, para. 1)*

Higher education for sustainable development (HESD) supports future change agents in acquiring the necessary competencies for undertaking the societal transition toward sustainability. This acquisition occurs predominantly on the micro-level of courses (with their topics, learning objectives, pedagogies and assessments), where the focus is on courses as well as their classroom- and out-of-classroom activities, teaching and learning processes. Attempts to integrate sustainability into the classroom have often brought an innovative element to teaching and learning settings, for example, by introducing an intercultural, interdisciplinary or problem-based perspective to higher education (Barth & Rieckmann, 2009; Caniglia et al., 2018; Wiek et al., 2014).

However, there is also a second, complementary macro-level to HESD on which institutional culture, drivers and barriers are of special interest. In research on HESD, this macro-level of curriculum change or development gained momentum because integrating education for sustainable development (ESD) is "[. . .] not just another issue to be added to an overcrowded curriculum, but a gateway to a different view of curriculum, of pedagogy, of organizational change, of policy and particularly of ethos" (Sterling, 2004, p. 50).

The latter topic is addressed in this paper via a systematic review to gain a better understanding of the sample universe of existing approaches to implementation of sustainability in higher education around the globe.

5.2.3 Theoretical Framework

Research on education for sustainable development in curricula builds on the tradition of broader curriculum change research (Barnett et al., 2001; Drake, 1998; Lattuca & Stark, 2009). Over the past decade, there has been a growing body of work on curriculum change processes in HESD (Blewitt & Cullingford, 2004; Corcoran & Wals, 2004; De La Harpe & Thomas, 2009; Leal Filho, 2000, 2009, 2010; Lozano, 2006; Thomas, 2004). Case study research plays a prominent role within this body of research. These case studies can be categorized into:

- single case studies that focus on one specific higher education institution (HEI) (Albareda-Tiana et al., 2018; Cebrián, 2017; Jones et al., 2008; Lidgren et al., 2006; Lozano & Young, 2013; Poon, 2017); or
- comparative studies that summarize insights based on a limited number of cases either within the same country (Sterling & Scott, 2008) or across countries (Ferrer-Balas et al., 2008; Junyent & Geli de Ciurana, 2008; Leal Filho et al., 2017).

These case studies offer two general insights. First, most of the case studies focus on internal and external factors of implementation (Littledyke et al., 2013; Timmerman & Metcalfe, 2009). Second, these case studies often merely tell a story, and only "[. . .] few studies have sought to go beyond description to include a critical and theoretical analysis of findings or to ground explanations in social or organisational theory" (Fien, 2002, p. 244).

More empirical research is needed on typical patterns of implementing HESD with respect to the form and extent of the implementation, the characteristics of the process, the role of drivers and barriers, as well as different institutions' coping strategies. Initial insights from single case studies suggest that there is a limited number of implementation patterns with specific characteristics. For instance, by using a small N of case studies in Germany, Barth (2013) explored three different patterns of how changing the curriculum toward embedding ESD can happen as:

(1) a student-led change from informal to formal learning;
(2) sustainability as a concern in campus operation; and
(3) sustainability as a unique selling point (Barth, 2013).

However, there is still a gap in understanding how curriculum change can best be pursued within these different patterns. Understanding the specific role of drivers and barriers in these patterns and how they influence curriculum development will enable planned interventions for curriculum change in the future.

What makes it difficult to understand patterns and draw conclusions is that studies on curriculum change are significantly differentiated and fragmented. Further there are mainly conducted within numerous individual studies that demonstrate a variety of existing approaches. A global and systematic overview of research on sustainability curricula implementation processes would enable reflection on the research field and current developments to draw further conclusions from what remains to be researched.

As higher education for sustainable development (HESD) becomes an established research field, systematic reviews are playing an increasingly important role. For instance, Barth and Rieckmann (2016) conducted a systematic literature review on HESD and demonstrated that HESD is an emerging field of research that is mainly characterized by descriptive studies (Barth & Rieckmann, 2016). A study by Kajikawa et al. (2014) also showed that ESD is an emerging small research cluster (Kajikawa et al., 2014). In other studies on global research landscapes of sustainability science, Yarime et al. (2010) revealed that there is an increasing number of HEIs that engage in sustainability research and that most of the output has been published by authors affiliated with North America, Europe (especially the UK, Germany, The Netherlands, France and Sweden), Australia and Asia (especially China and Japan) (Yarime et al., 2010).

While research on sustainability curricula implementation processes is recognized as being an important and significant part of research on HESD, there has not yet been any detailed mapping of how and where such processes occur. To better geographically locate where higher education institutions (HEIs) are implementing sustainability curricula, a number of networks have begun

aggregating and documenting such cases. For instance, the Copernicus Alliance network for Europe, the network for the promotion of sustainability postgraduate education and research (ProSPER.net) for the Asia–Pacific region, the African network for Sustainable Development Education (RAEDD) and the Association for Advancement of Sustainability in Higher Education (AASHE) (with a special focus on North America) all began with overviews of relevant HEIs. Further endeavors to collect research on case studies have been undertaken by specialized edited volumes, such as the "World Sustainability Series" (Leal Filho, 2015, 2018) and "Environmental Education, Communication and Sustainability Series" (Leal Filho, 2010, 2012).

While attention has been given to small N comparative approaches that focus on a few HEIs in one or various countries, applying a reliable methodology to map a global research landscape of sustainability curricula implementation processes in HEIs has not yet occurred. The study presented here intends to close this research gap by analyzing the global research landscape in terms of a cross-country distribution and a general development trend of the research field.

5.2.4 Research Method

A systematic review was carried out to explore the scope of case studies that report on sustainability curricula implementation processes in higher education. The term "sustainability curricula implementation processes" refers solely to the education level, which is defined as "[. . .] the development and implementation of new approaches to teaching and learning 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). In this context, the "implementation process" is understood to be an institutional implementation process with various drivers and barriers.

The term "higher education" refers to institutions that offer at least a bachelor's degree.

Data collection

Due to the involvement of many academic disciplines in higher education for sustainable development (HESD), the data were likely to be fragmented between many sources. A systematic review approach was therefore chosen that aimed "[. . .] to comprehensively locate and synthesize research that bears on a particular question, using organized, transparent, and replicable procedures at each step in the process" (Littell et al., 2008, p. 1).

For the structured collection of data, desk research was conducted to identify research papers that report on sustainability curricula implementation processes. A paper counted as relevant if the following inclusion criteria were applicable:

- the overall topic was on HESD;
- at least one specific case (HEI) was mentioned;
- the focus was on reporting, analyzing, or discussing a case-specific sustainability curricula implementation process; and
- the articles and reviews were published in English between 1990 and 2017.

To compile a sample universe as comprehensively as possible, the data collection process was structured as follows (Figure 5.1). In a first step, selected journals dedicated to HESD were reviewed. The identified journal selection was based on previous research (Barth & Michelsen, 2013; Barth & Rieckmann, 2016) and reflected the highly relevant journals in this field of research. All selected journals were searched via a review of tables of contents and abstracts; however, due to the large number of data, two journals (Environmental Education Research and Journal of Cleaner Production) were initially searched via a search string in the title, abstract and keywords and were subsequently reviewed based on abstracts (for details on keywords, see Figure 5.1).

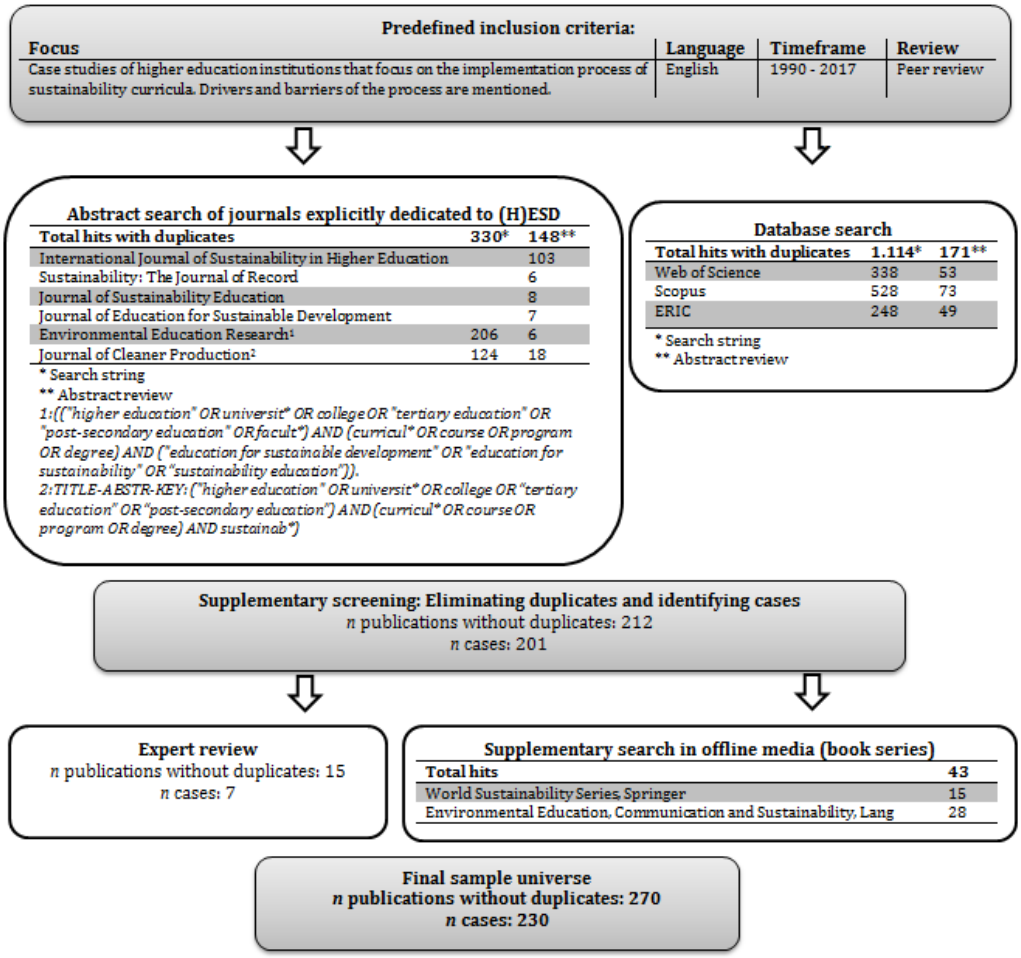


Figure 5.1 Search strategy for structured data collection

Second, supplementary search queries were applied in three bibliographical databases: Scopus, Web of Science and Education Resources Information Center (ERIC). Scopus and Web of Science were selected as the two largest databases representing social sciences and sustainability sciences. ERIC was chosen as it covered research collections in educational science. The following search string was applied in all three databases with a few adjustments depending on the different functions: TITLE-ABS-KEY (("higher education" OR universit* OR college OR "tertiary education" OR "post-secondary

education" OR facult*) AND (curricul* OR course OR program OR degree) AND ("education for sustainable development" OR "education for sustainability" OR "sustainability education")).

In a final step, the sample universe was reviewed and complemented in two ways. First, an expert review was carried out by ten experts in the field of HESD from around the globe who were asked to identify missing cases and publications. Second, to add supplementary data published in offline media, relevant edited volumes were researched via reviews of tables of contents and abstracts. The final sample universe added up to 270 publications without duplicates and included 230 cases (Figure 5.1)

Data analysis

A database was created from all of the publications and included bibliographical data, the abstract and the full text. Additional variables for investigating the research focus were created, including the country and the name of the higher education institution (HEI). The sample of publications was identified and coded by a trained team consisting of three student assistants and one of the authors. All cases identified as relevant were double checked by one of the authors.

The distribution of case studies was analyzed via descriptive statistics. Additionally, bibliometric analyses conducted in R and VosViewer added to the findings and enabled greater insight into the publication trends of the articles of interest and of journals as well as into influencing factors within the research area.

5.2.5 Findings

The identified sample consisted of 270 publications representing 230 unique cases. In total, 85 per cent of these publications focused on one specific higher education institution (HEI), whereas 15 per cent were comparative case studies covering more than one HEI. To provide a mapping of the research landscape of sustainability curricula implementation processes, the following results first show the global distribution of case studies. A bibliometric analysis of the publication trend, key journals and investigations on what influences the research field most also added to the findings.

How are case studies on sustainability curricula implementation processes in higher education institutions distributed globally?

The literature review identified 230 case studies worldwide whose distribution varied widely across regions (Figure 5.2). Each case represents a higher education institution (HEI) for which peer-reviewed publications on the HEIs' specific sustainability curricula implementation process were identified. Most case studies were published on North American (n = 76) and European (n = 71) HEIs, many were published on Asian HEIs (n = 41), less were published on HEIs in Oceania (n = 22), and very few were published on Latin American and Caribbean HEIs (n = 13) or African HEIs (n = 7). The detailed number of cases per country and the affiliated region based on the UN geographical regions (UN,

2018) is shown in Figure 5.2. Overall, it is clear that the global distribution of research on HEIs that implement sustainability curricula varies both across and within regions. Moreover, many blind spots are evident. For instance, many countries in Latin America and Africa are not represented. Possible reasons for this irregular representation are specified in the discussion section.

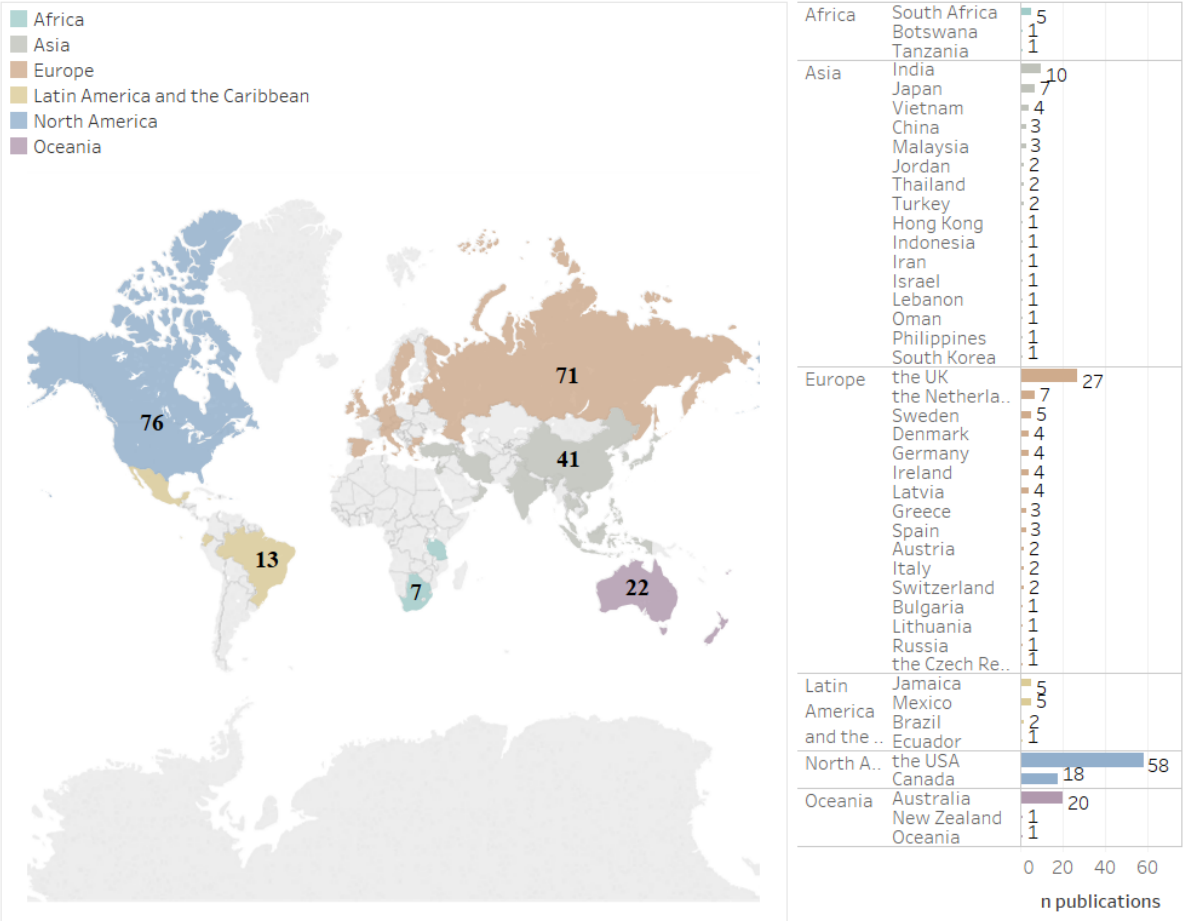


Figure 5.2 Cross-country distribution of sustainability curricula implementation processes in higher education institutions. Based on peer-reviewed case studies published between 1990 and 2017, the map was designed using Tableau software

While a perspective on global distribution provides valuable insights, it does not reveal the significance that these cases have in different countries. For this purpose, other factors – such as the number of HEIs in a given country – have to be considered to report on the extent to which a country implements education for sustainable development (ESD) or the research performed on sustainability curricula implementation processes. To better understand these elements, a closer look is taken at three different countries that represent the global areas of North America, Germany and Australia. Each of these countries has a long tradition of integrating environmental and sustainability aspects into higher education. Furthermore, the authors are familiar with the higher education area in all three countries due to their own experience and research and can make

evidence-based assumptions. In the following Table 5.2, these three countries are described in terms of some salient aspects – such as the country-specific context and the number of HEIs in the country – that should be considered when comparing countries. Moreover, the cases in the sample are succinctly characterized to provide an idea of what types of institutions are displayed in the sample.

Table 5.2 Closer characterization of 3 countries: Australia, Germany, the USA

	AUSTRALIA	GERMANY	USA
N HEIS IN COUNTRY	143 HEIs (private:6, public: 38; other: 99)[1]	105 HEIs (except for universities of applied science) (public: 87)[3]	3,039 4-year colleges (public: 691, private: 2,348)[5]
STUDENTS ENROLMENT IN COUNTRY	2016: 1,034,916 -majority of students (952,144) at public HEIs[1]	2017: 2,842,225 -majority of students (1,782,369) at public HEIs[3]	2016: 19,841,014[5]
SUSTAINABILITY STUDY PROGRAMS IN COUNTRY	62 study programs with the keyword sustainab*, and 414 with the keyword environment* [2]	177 study programs with the major or minor topic sustainability[4]	1,525 study programs with the topic sustainability[6]
RATIO N CASES IN SAMPLE/ N HEIS COUNTRY	20 cases → 52.63% of all public HEIs are displayed in the sample	3 cases (except one university of applied science) → 3.4% of all public HEIs are displayed in the sample	58 cases→ 1.9%
SIZE OF HEIS LARGE (> 30,000 STUDENTS) MEDIUM (≥ 12,000 STUD.) SMALL (≥ 5,000 STUD.) VERY SMALL (≥ 5,000 STUD.)	Large: 14 HEIs (70%) Medium: 6 HEIs (30%)	Medium: 2 HEIs (50%) Small: 1 HEI (25%) Very small: 1 HEI (25%)	Large: 12 HEIs (21%) Medium: 24 HEIs (41%) Small: 12 HEIs (21%) Very small: 10 HEIs (17%)
FOCUS OF HEIS	Range from research-oriented universities to more industry-based universities	Range from research-oriented universities to a university with a clear sustainability focus and a small institution dedicated to applied science	According to the Carnegie classification, nearly 60% are research-focused institutions
GEOGRAPHICAL DISTRIBUTION	Evenly geographically distributed	The geographical distribution of the cases is spaced out evenly (North, South, West, East), but not every state is pictured in a small N of cases	Spaced out evenly but reveals that some states are missing in the sample
SHANGHAI RANKING	14 of 20 (70%) HEIs are listed; 3 HEIs in the top 100	1 HEI (25%) is listed	29 HEIs are listed (50%), 14 HEIs in the top 100

Notes: [1] Australian Government, Department of Education and Training, 2016; [2] Online search in study program database (Australian Government, 2018), [3] Statistisches Bundesamt (2018); [4] Online search in study program database, topic: sustainability (Hochschulkompass, 2018); [5] U.S. Department of Education, National Center for Education Statistics (2016a, 2016b); [6] Online search in study program database (Association for the Advancement of Sustainability in Higher Education [AASHE], 2018).

What does data on these three countries tell us?

Australia has a higher percentage of cases than do Germany and the USA due to its comparably limited number of higher education institutions (HEIs) and to an implementation of higher education for sustainable development (HESD) that began early and with wide dispersion (Table 5.2). In

contrast, the USA has a large number of HEIs and sustainability study programs, but the ratio of the number of cases to the number of HEIs reveals that HESD has not yet been fully implemented. For Germany, the data show a low number of cases and a high ratio of sustainability programs to HEIs. The number of cases reveals where research has been performed and not necessarily where students can study sustainability topics. Beyond the country-specific distribution, there does not seem to be a direct dependency between the integration of HESD and the HEI size or reputation according to rankings.

When and where are cases documented?

The number of case studies on sustainability curricula implementation in higher education per year increased nonlinearly from 4 publications in 1999 to 15 in 2017, with a peak of 37 publications in 2015 (Figure 5.3). The causes of the peaks cannot be investigated by bibliometry, but it is conceivable based on the data that the number of manuscripts from the IJSHE and edited volumes corresponds with some peaks. The data suggest that the IJSHE was crucial to the beginning of the publication process in peer-reviewed journals and characterizes the entire publication process between 1999 and 2017, with a peak of 11 case studies in 2004. The edited volumes (Environmental Education, Communication and Sustainability and World Sustainability Series) appear to also have been important at the beginning of the research trend, with a peak of 10 case studies in 2002.

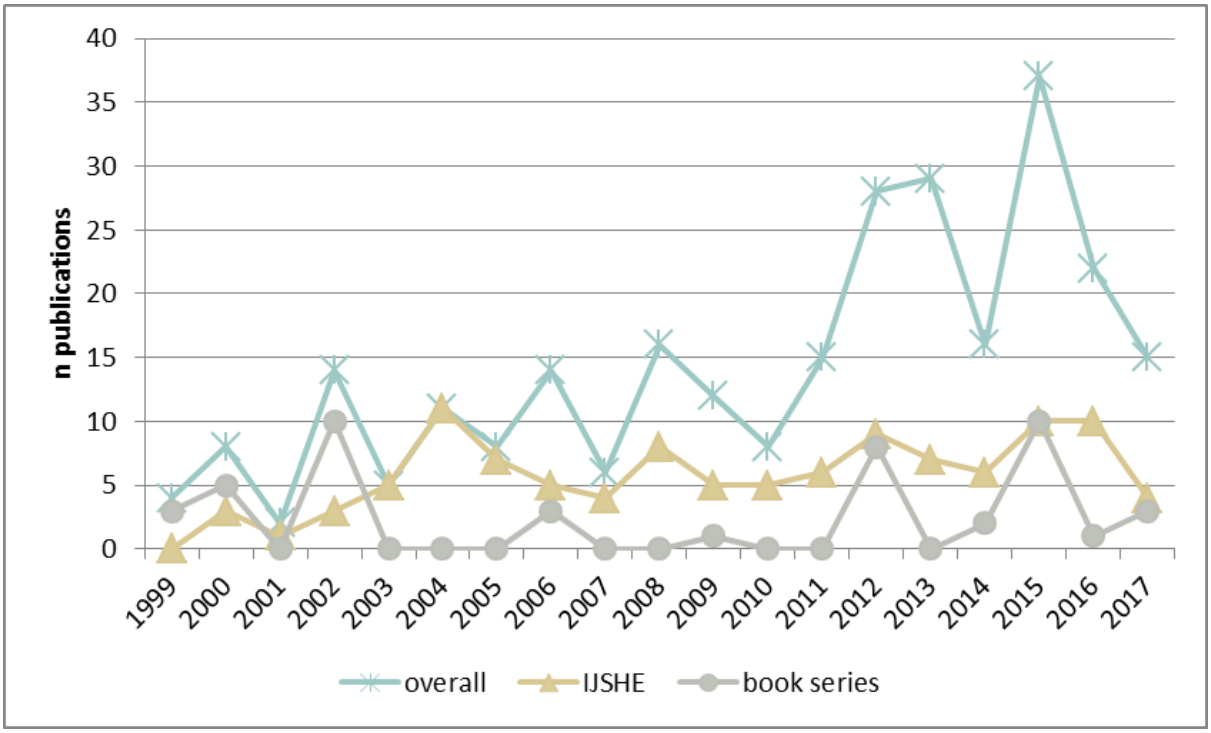


Figure 5.3 Time curve of case studies on sustainability curricula implementation processes in higher education institutions. Based on peer-reviewed case studies published between 1990 and 2017

The number of academic journals also increased from 1 Journal in 1999 (European Journal of Engineering Education) to 10 journals in 2017, with a peak of 14 different journals in 2013. Overall, 46 different journals between 1999 and 2017 published case studies on sustainability curricula implementation processes in higher education. Most of the case studies were published in 9 key journals (Table 5.3). With 109 out of 270 publications, the *International Journal of Sustainability in Higher Education* is the most dominant journal, followed by the *Journal of Cleaner Production* (with 23 publications) and 7 other key journals. A detailed examination of the time span of the 9 key journals reveals that until 2008, 4 key journals had been involved in publishing case studies on sustainability curricula implementation in HEIs and 5 further key journals have gotten involved since 2008. In total, 4 of these 5 key journals were founded in 2006 or later, and nearly all have a specific focus on sustainable development and education. Despite these key journals, the distribution is very scattered, with 37 other journals having produced less than 5 publications on sustainability curricula implementation in HEIs. The foci of the journals are broad, which was investigated based on the journals' names. Only one journal has a clear focus on higher education for sustainable development, and some focus on education for sustainable development and environmental education. Many other journals focus on educational science, with specializations in management, higher education or engineering education, or are characterized by a discipline orientation without an educational link and vary from social science and management to sustainability science. Moreover, the edited volumes (Environmental Education, Communication and Sustainability and World Sustainability Series) play an important role in 47 of the 270 publications.

Table 5.3 Key journals for case studies on sustainability curricula implementation processes in higher education institutions

Journal	**n publications**
International Journal of Sustainability in Higher Education	109
Journal of Cleaner Production	23
Environmental Education Research	8
Journal of Education for Sustainable Development	8
Journal of Sustainability Education	8
Sustainability: The Journal of Record	6
Australian Journal of Environmental Education	5
Journal of Teacher Education for Sustainability	5
European Journal of Engineering Education	5
37 other journals	46
Book series	47
Overall publications	270

Notes: Based on peer-reviewed case studies published between 1990 and 2017.

How are cases linked, and how do they learn from each other?

Communication between scientists mainly happens via journal publications. The influence of researchers can be indicated by the number of their publications and the number of citations of these

publications, which signifies the range of other researchers who have taken these publications into account. To identify what influences the research field, key publications were identified, and a citation network was calculated. Both analyses were run with publications indexed in Scopus, which included 184 of the 270 publications.

11 key publications with a threshold of 50 citations were identified within the dataset (Table 5.4). The regions, countries, and affiliations were retrieved for all collaborating authors. Nearly half of the publications were published by European authors (n = 5), 2 were published by North American authors, 1 was from Australia and 3 contributions came from international collaborations. The European authors came from The Netherlands, Sweden, Spain, the UK, Germany and Switzerland. Canada and the USA represented the North American authors, and Asia was represented in the collaborative publications by authors from Japan and India. The regions of Latin America and Africa were not represented.

A citation network based on countries is able to offer insights useful in analyzing how knowledge spreads geographically. The network analyses of citations between the countries in the sample revealed imbalances between the countries (Figure 5.4). For the analysis, 39 countries with at least one document and one citation were chosen. In total, 34 of the 39 countries were connected to one another through citations. The size of the dots and the country names were determined by the weight of the item, which was calculated via the number of citations. The color was determined by a calculation of the average number of citations. The lines illustrate the link (number of citations) between two countries, and the thickness of the lines indicates the strength of the link. When interpreting the results, it should be noted that only citations between countries within the database are possible and that the analysis is affected by the bibliometric database coverage, which largely indexes journal articles.

In the network, it is clear that the so-called "Western world" has the greatest number of citations, which indicate the international visibility of their research activities. Additionally, the "Western" countries are quite well interlinked with one another, whereas countries such as Russia, Iran, Jordan, the Philippines and Oman have no citation links to other countries, and countries such as Latvia, Lithuania and Jamaica are linked to only one country with a high impact, including Japan, The Netherlands, Australia, Sweden, Spain, the USA, the UK and Germany. It is surprising that countries located next to one another (e.g., Latvia, Lithuania, Russia, and the Czech Republic) do not cite each other's work. Australia, the USA, the UK, The Netherlands, Sweden, Canada and Spain have the highest total link strength and are very well interlinked with many countries (Figure 5.4).

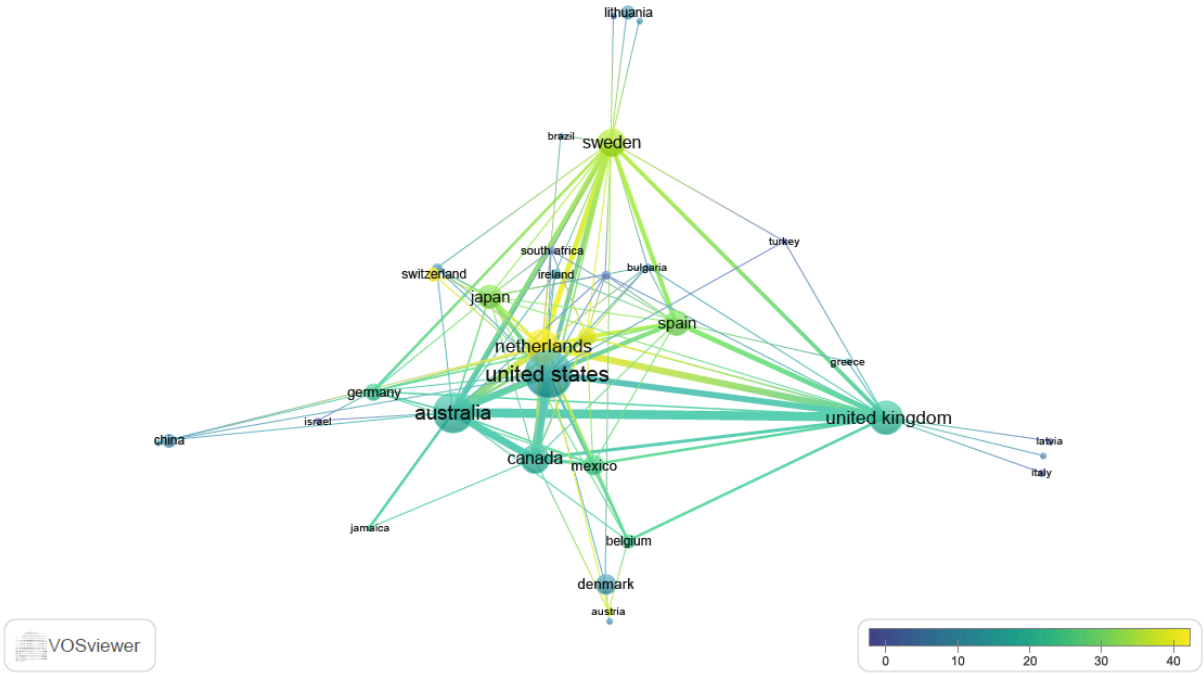


Figure 5.4 Citation network between countries engaged in sustainability curricula implementation research. Included articles are based on peer-reviewed case studies on sustainability curricula implementation processes in higher education institutions published between 1990 and 2017 that are indexed in Scopus. The country is determined by the affiliation of the first author. The network is calculated in VosViewer.

Table 5.4 Highly cited references

Document	Region	Country	Affiliation	n Citations (1990–2017)
Thomas, I. (2004). Sustainability in tertiary curricula: what is stopping it happening?. *International Journal of Sustainability in Higher Education*, *5*(1), 33-47.	Australia & Oceania	Australia	RMIT	110
Ferrer-Balas, D., Adachi, J., Banas, S., Davidson, C. I., Hoshikoshi, A., Mishra, A., Motodoa, Y, Onga, M., & Ostwald, M. (2008). An international comparative analysis of sustainability transformation across seven universities. *International Journal of Sustainability in Higher Education*, *9*(3), 295-316.	Europe,[2] Asia,[5] North America[2]	Spain, Japan,[4] The USA,[2] India, Sweden	Technical University of Catalonia, The University of Tokyo,[3] Carnegie Mellon University, TERI University, Hokkaido University, Linköping University	99
Brundiers, K., Wiek, A., & Redman, C. L. (2010). Real-world learning opportunities in sustainability: from classroom into the real world. *International Journal of Sustainability in Higher Education*, *11*(4), 308-324.	North America	The USA	Arizona State University	99
Moore, J. (2005). Seven recommendations for creating sustainability education at the university level: A guide for change agents. *International Journal of Sustainability in Higher Education*, *6*(4), 326-339	North America	Canada	Simon Fraser University	88
Van Weenen, H. (2000). Towards a vision of a sustainable university. *International Journal of Sustainability in Higher Education*, *1*(1), 20-34.	Europe	The Netherlands	University of Amsterdam	85
Lidgren, A., Rodhe, H., & Huisingh, D. (2006). A systemic approach to incorporate sustainability into university courses and curricula. *Journal of cleaner production*, *14*(9-11), 797-809.	Europe	Sweden	Lund University	83
Fenner, R. A., Ainger, C. M., Cruickshank, H. J., & Guthrie, P. M. (2005). Embedding sustainable development at Cambridge university engineering department. *International Journal of Sustainability in Higher Education*, *6*(3), 229-241.	Europe	The UK	Cambridge University	80
Barth, M., & Rieckmann, M. (2012). Academic staff development as a catalyst for curriculum change towards education for sustainable development: an output perspective. *Journal of Cleaner Production*, *26*, 28-36.	Australia & Oceania, Europe	Australia, Germany	RMIT University, Leuphana University	55
Yarime, M., Trencher, G., Mino, T., Scholz, R. W., 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. *Sustainability Science*, *7*(1), 101-113.	Asia,[3] Europe[5]	Japan,[3] Switzerland, Sweden,[2] The Netherlands[2]	University of Tokyo,[2] ETH Zürich, Lund University,[2] Erasmus University Rotterdam[3]	56
Holmberg, J., Svanström, M., Peet, D. J., Mulder, K., Ferrer-Balas, D., & Segalàs, J. (2008). Embedding sustainability in higher education through interaction with lecturers: Case studies from three European technical universities. *European Journal of Engineering Education*, *33*(3), 271-282.	Europe[6]	Sweden,[2] The Netherlands,[2] Spain[2]	Chalmers University of Technology,[2] Delft University,[2] Polytechnic University of Catalonia[2]	56
Peet, D. J., Mulder, K. F., & Bijma, A. (2004). Integrating SD into engineering courses at the Delft University of Technology: The individual interaction method. *International Journal of Sustainability in Higher Education*, *5*(3), 278-288.	Europe[3]	The Netherlands[3]	Delft University of Technology[2]	51

Notes: Based on peer-reviewed case studies on sustainability curricula implementation processes in higher education institutions published between 1990 and 2017 that are indexed in Scopus. The superscript numbers behind the countries indicate the number of authors from that country, no number equals one author

Analysis also revealed that different terminology is used to refer to sustainability curricula implementation in different regions. Terminology was analyzed based on word counts in titles and abstracts. In North America, "sustainability education" (SE) is the most commonly used term, whereas in Australia and Oceania, the term "education for sustainability" (EfS) is used, and in Europe, Asia and Latin America and the Caribbean, the term "education for sustainable development" (ESD) is generally used. In Africa, ESD and SE are used with nearly equal frequency.

5.2.6 Discussion

Limitations of the case universe

A systematic review approach is generally well suited for collecting publications that are dispersed and should reduce bias in the selection of publications (Littell et al., 2008). However, as the field of case studies is very diverse and publications are distributed around many sources, it is impossible to collect all published case studies from around the globe due to some limitations. First, the sample is biased by the selection criteria that were used. The search only collected publications in English, which likely lead to a lack of cases from Latin American, in particular. Including articles published in other languages could change the global distribution of the research landscape and could lead to a more salient contribution from other countries. This limitation is recognized, and there is a need to further integrate a more complete sample into future studies. At the same time, this imbalance is typical in academic journals and is also reflected in the manner by which case studies are referenced and cited. Nevertheless, a stronger representation of cases and authors from the "non-Western world" in key journals would support a greater recognition and a North–South dialogue of context-dependent sustainability curricula implementation processes.

Furthermore, due to the specific terminology of the search string, the case universe is biased regarding the concept of education for sustainable development (ESD). Nevertheless, this focus was deliberately chosen to enable the investigation of the research landscape of sustainability curricula. However, there are other valid concepts, such as environmental strengthening of higher education institutions (HEIs) or curricular environmentalization, neither of which is fully reflected in the sample.

Additionally, the vast array of journals and the peer-review restriction may have led to missing cases since some journals may not have been indexed in the databases. For instance, student-led research into implementation processes in HEIs are not likely to be published in peer-reviewed journals. To counteract the scattered nature of the publications, HESD experts were asked to review the sample, which led to the inclusion of additional publications and cases.

Research on sustainability curricula implementation in higher education institutions is an emerging field of research

The systematic review found that the research on sustainability curricula implementation process in HEIs began to emerge in 1999 and has produced a steadily growing output of publications. This clearly indicates that there is a growing number of journals dedicated to higher education for sustainable development (HESD). Sustainability curricula implementation processes are one of the key topics that are researched in HESD, which is in line with earlier findings on general publication trends of the (H)ESD research area (Barth & Michelsen, 2013; Barth & Rieckmann, 2016; Vaughter et al., 2013). Besides quantity, another key finding is that case studies on sustainability curricula implementation processes are being published in a broad range of journals from different disciplines and communities. The increasing number of different journals clearly indicates that curriculum development in HESD is an interdisciplinary topic that is published in various disciplinary and interdisciplinary journals. At the same time, this large number of journals leads to a very broad field of case studies. Even though sustainability curricula implementation processes figure prominently in the key journals of HESD research, a complete picture of these cases is difficult to ascertain.

The global distribution of case studies is imbalanced

The analysis of existing case studies on sustainability curricula implementation reveals a considerable imbalance of the global distribution of documented cases. There is a dominance of cases from the USA, Europe, and Asia. At the same time, significant areas around the globe – such as Africa and Latin America – are largely underrepresented. While this underrepresentation reflects a general imbalance in published research around the globe that can also be studied in other areas of (sustainability) research (Hou et al., 2015; Liu et al., 2011) and is apparent in research on higher education for sustainable development (HESD) in general (Barth & Rieckmann, 2016), it also severely limits the understanding of curricula implementation processes on a global level.

Given the imbalanced distribution of case studies and context-dependent implementation processes, it appears that much remains to be learned, especially for cases in Africa and Latin America. This finding is affirmed on a policy level by UNESCO, which emphasizes the notion that local, national, regional and global contexts should be taken into consideration for fostering sustainability curricula implementation (UNESCO, 2016). The UNESCO Global Action Program on Education for Sustainable Development (GAP), which "[. . .] focuses on generating and scaling up ESD action at all levels and in all areas of education, and in all sustainable development sectors" (UNESCO, 2016, p. 3), stresses the idea that developed and developing countries – especially Small Island Developing States and the Least-Developed Countries – should engage in intensifying efforts for ESD (UNESCO, 2016, p. 5). Transforming learning and training environments is one of five priority action areas, and all HEIs are called upon to engage in "[. . .] collaborative and transformative knowledge production [and] dissemination, [. . .]" (UNESCO, 2016, p. 5).

The publication of "more of the same" (i.e., case studies largely from "Western" countries) would likely add very little to our understanding of this topic; rather, it seems more pressing to support research that more strongly considers regional contextual factors in countries that have not yet been as well examined. Approaches such as the SARUA project in Southern Africa (www.sarua.org/) might represent one option of overcoming these limitations.

The presented data provide valuable insights into the research landscape, but due to the different distribution of higher education institutions (HEIs) worldwide, the data should not be interpreted as a ranking across countries or regions but rather as a reflection of where research on sustainability curricula implementation processes is happening and where blind spots can be observed. To a certain degree, conclusions can also be drawn regarding where sustainability curricula are implemented in HEIs in practice. To draw conclusions regarding the density that a country reports and its research on sustainability curricula implementation processes, the identified case studies have to be examined in relation with the overall number of HEIs in the specific country. This point was clearly illustrated by examining the three countries in more detail, which revealed that in proportion with the overall number of HEIs in the country, Australia has a significantly higher rate (52.63 per cent) in terms of research and implementation in practice (on the basis of the case universe) than do the other two countries. The data reveal where research is happening but not necessarily where sustainability study programs or topics are offered. The numbers of sustainability-related study programs that are revealed by country-specific databases provide an idea of the number of sustainability study programs, but comparable data would need additional exploration with a detailed review of study programs. Additionally, further research would be required to examine how many students from the student population are offered the opportunity to study sustainability topics.

Influencing factors within the research area

Eleven highly cited key publications were identified within the sample universe. The authorship of these publications is dominated by researchers from European, North American, Australian and Asian countries. The research area is obviously mostly influenced by authors from the so-called "Western world", whose output is highly visible. This fact also is visible in the citation network, where these authors are highly cited overall and rather strongly connected via citations. In contrast, there are many countries that are not at all or only poorly linked to one another. It is interesting to note that some developing countries and countries that are geographically located next to one another do not cite one another's work. However, the results should be considered against the background of the lack of an accepted theory that explains citation behavior (Case & Higgins, 2000). Potential linkages may be reduced due to the different terminology that is used for education for sustainable development (ESD). Researchers and higher education institutions (HEIs) would only be able to learn from other cases if the diverse terminology were transparent, which would enable the use of different terms in search engines to include research from other regions.

In terms of authorship, the findings align with the results from other bibliometric analyses of the global landscape of sustainability research (Kajikawa et al., 2014) and global patterns of collaboration in sustainability science (Yarime et al., 2010). These studies found that an increasing number of HEIs engage in sustainability research, and most articles are published by authors affiliated with North America, Europe (especially the UK, Germany, The Netherlands, France and Sweden), Australia and Asia (especially China and Japan). Yarime et al. (2010) analyzed collaboration patterns and found that international collaboration patterns indicate that countries located geographically next to one another tend to work together, whereas communication exchange within larger regional clusters (EU and Africa, North and South America, Asia Pacific) might be limited (Yarime et al., 2010).

Given the sparse interlinkages in the citation network of this sample, sharing information between and learning from many of the cases is likely to be limited. The question remains as to how cases learn from one another globally, locally and within networks. Do cases within the same country learn from one another, or are the experiences from HEIs that are fairly equal in size and structure or have similar contextual factors taken into account?

5.2.7 Conclusion

By mapping out the current global research landscape on sustainability curricula implementation processes in higher education, this systematic review offers a source of reflection on how this research area is developing. A steadily growing number of case studies – mainly in North America, Europe and Asia – have been carried out since 1999. This publication trend indicates that sustainability curricula implementation in higher education has gained momentum and that many HEIs around the world have initiated attempts to integrate sustainability. Nevertheless, experiences from many countries and regions (e.g., Africa, Latin America and the Caribbean) are underrepresented. A similar pattern can be seen via citation analysis, in which a "Western" influence is apparent. The citation network analysis leaves unanswered the question of how cases learn from one another as the results reveal that "non-Western" countries, in particular, are not well interlinked.

These results offer guidance for the direction of future research. First, there is a clear need to better understand implementation processes in countries that remain underrepresented. In line with the aims of the UNESCO GAP, more research and funding would assist in advancing research on sustainability curricula implementation that is equally globally distributed. Second, because this review has drawn on peer-reviewed English-language literature, complimentary research would involve the examination of other publication formats – such as master's theses, conference proceedings and gray literature, as well as publications in other languages – to provide a more comprehensive overview. Third, to understand the density of research on and the implementation of sustainability curricula better, country-specific factors like the number of higher education institutions (HEIs), the number of sustainability programs at each HEI, the country's budget for research and HESD and governmental policies to support HESD should be further investigated. Fourth, there is a need to take a closer look how countries learn from one another's experience, for

example, if and why countries establish more connections with some of them than with others and what the implications are. Fifth, to learn how to change HEIs, it is important to conduct research on various context-specific individual sustainability curricula implementation processes, but it is even more important to learn from these experiences and to understand how such implementation can be strategically supported. Thus far, the research field remains quite fragmented, and there is little evidence of what the process to follow should be. This database offers a starting point for further comparing and analyzing these processes of change to identify specific implementation patterns from which other HEIs can learn.

5.3 Study/Article 2: Drivers and Barriers of Implementing Sustainability Curricula in Higher Education – Assumptions and Evidence

Marie Weiss, Matthias Barth, Arnim Wiek, Henrik von Wehrden

5.3.1 Abstract

Progress on the Sustainable Development Goals (SDGs) depends, in part, on the sustainability competencies of professionals in various fields, and thus, on the implementation of sustainability curricula in higher education. While many universities now offer sustainability curricula, and many more aspire to, there is a lack of evidence on what supports or hinders such implementation. This article presents a meta-study on 133 case studies from universities around the world and synthesizes the main drivers and barriers, identifies information gaps, and tests prominent assumptions on implementing sustainability curricula in higher education. The findings confirm that such implementation is associated with strong leadership by the university; incentives and support through professional development; concurrent implementation of sustainability in research, campus operations, and outreach; formal involvement of internal and external stakeholders as well as sustainability champions, among others. Common research protocols for case studies are needed to yield comparable data on these influencing variables and to enhance reliability of cross-case comparisons. Most sustainability programs could utilize the findings for informing their implementation processes.

Keywords: barriers, curriculum change, drivers, education for sustainable development, universities, sustainability, higher education institutions, meta-analysis, sustainability curricula implementation process

5.3.2 Introduction

The Relevance of Higher Education for Sustainability

Pressing sustainability challenges such as climate change, loss of biodiversity, socio-economic injustices, and currently a pandemic call for accelerated progress on the Sustainable Development Goals (SDGs) (UN, 2020a). Sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED World Commission on Environment and Development, 1987, chapter 2, para. 1) - and operationalized through the SDGs. Higher education institutions (HEIs) act as an important catalyst to initiate and establish sustainable development (Sachs et al., 2019) as it is primarily in higher education that tomorrow's professionals and potential change agents are educated in a variety of disciplines to take on core positions in society (Haigh & Clifford, 2011). Education for sustainable development (ESD) develops students' competencies for supporting and advancing sustainable development (Holdsworth & Thomas, 2020; Shephard et al., 2019). For a true transformation,

innovative teaching and learning approaches - with space for the learner's critical reflection on assumptions and values - are the most promising means to challenge established ontologies and epistemologies (see also Table 5.5). Yet, ESD is "not just another issue to be added to an overcrowded curriculum, but a gateway to a different view of curriculum, of pedagogy, of organizational change, of policy and particularly of ethos" (Sterling, 2004, p. 50).

Therefore, the most profound approach to ESD in HEIs is anchoring sustainability on the curriculum level (Barth, 2015). In the following we understand implementation process(es) of sustainability curricula as "[…] the development and implementation of new approaches to teaching and learning (courses and programs) 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). In this context, the implementation process is understood to be an institutional implementation process with various internal and external drivers and barriers.

A number of HEIs have begun to implement sustainability curricula, using different processes and yielding different outcomes (Lozano et al., 2015; Wals, 2009). Empirical research on implementation has focused on single or a small number of cases. Hence, there is a need for a meta-study to derive general insights on implementing sustainability curricula (Barth & Thomas, 2012; Fien, 2002).

This meta-study analyses 133 case studies worldwide, addressing the following research questions:

(1) *What are the most common drivers and barriers of implementing sustainability curricula in HEIs?*
(2) *Do the findings confirm existing assumptions on drivers and barriers of implementing sustainability curricula in HEIs?*

Data analysis included: (a) synthesizing the most common drivers and barriers (top-ten list) (frequency analysis); (b) rating the level of implementation (case survey coding process); and (c) linking drivers and barriers to the implementation levels (chi-square tests).

The findings could be used to enhance the institutional anchoring of existing sustainability programs as well as guide universities that aspire to implement a sustainability curriculum in the future.

State of Research on Implementing Sustainability Curricula

Sustainability curricula can be implemented to different degrees or levels in HEIs. One of the most established concepts for describing the types of educational responses to sustainability in higher education is provided by Sterling and Thomas (2006) (Table 5.5), ranging from denial (no change), "bolt-on'" (education about sustainability), "build-in" (education for sustainability), and redesign (education as sustainability). Full implementation (redesign) anchors sustainability at the core of the HEI, extending beyond education into all domains of the institution. This change is transformative, affects university leadership, faculty, students, and staff. A redesign of curricula is also linked to innovative and transformative teaching and learning approaches. To change epistemological assumptions a shift needs to take place moving from first-order learning to third-order learning (Mochizuki & Yarime, 2016).

Table 5.5 Levels of implementing sustainability curricula in HEIs

Level		Type of ESD	Description	Pedagogical Approach
high/ very strong	redesign	education *as* sustainability	-holistic change and paradigm shift that places sustainability principles, ethics, and values at the core of the curriculum requiring the engagement of the whole person and institution -ESD is integrated into common core requirements and/or the vision of the HEI	emancipatory & transformative (third-order learning)
middle / strong	"build-in"	education *for* sustainability	-significant changes to the curriculum by including a coherent coverage of content, values, and skills associated with sustainable development and a critical questioning of assumptions -sustainability is addressed in (interdisciplinary) programs/courses focusing on integrating sustainability issues -first linkages from ESD modules to other HEI areas such as operations/campus	
low/ weak	"bolt-on"	education *about* sustainability	-leaves current paradigm change unchallenged -sustainability concepts are added to specific disciplinary existing courses or programs (content based sustainability literacy) -minimal effort from the institution	instrumental & simplistic (first-order learning)
very weak	denial	no change	/	

Adapted from Sterling (2001), Sterling and Thomas (2006)

HEIs, however, are often resistant to change (Evans & Henrichsen, 2008). Numerous stakeholders with different interests, values, and attitudes are required for curriculum changes (Blanco-Portela et al., 2017; Cortese, 2003), which makes implementing sustainability curricula challenging (Thomas, 2016).

Building upon broader curriculum change research (Barnett et al., 2001; Geschwind, 2019; Keesing-Styles et al., 2014; Lattuca & Stark, 2009), a number of studies have been conducted on implementing sustainability curricula in HEIs (Barth et al., 2016; Weiss & Barth, 2019). In particular supporting and hindering factors have been studied through literature reviews (Velazquez et al., 2006), individual case studies (Cebrián, 2017), comparative small-N case studies (Ralph & Stubbs, 2014), theoretical models (Barth, 2015), and a large survey focused on barriers (Ávila et al., 2017).

A logic model of curriculum change (Barth, 2015) links various elements: At the center are faculty's willingness to advance their competence in teaching sustainability, students' interest in sustainability, and leadership's (presidential level) support of the implementation. External factors include laws, accreditation, public funding, employers' expectations, and public recognition. Pressure

from external actors or internal changes in leadership opens windows of opportunity to advance implementation of sustainability curricula. Within the HEI, priority setting in vision and mission (strategic planning), available resources, teaching and learning culture, (inter)disciplinary structure, and institutional routines such as communication flows and a competitive or collaborative environment play important roles for the implementation process.

Below, we present prominent assumptions on drivers and barriers extracted from previous studies.

The Role of Incentives and Professional Development

Incentives and professional development are identified as either important preconditions or drivers of change in higher education in general (Geschwind, 2019), and implementing sustainability curricula in particular (Lidgren et al., 2006; Ralph & Stubbs, 2014). Examples of incentives include awards for innovative teaching approaches, workload reduction for curriculum redesign, financial incentives or promotion incentives (Ferrer-Balas et al., 2008). Professional development includes faculty trainings or individual coaching that motivate and support faculty to implement sustainability across the curriculum (Barth & Rieckmann, 2012). From this review, we derive:

Assumption 1 – The more incentives and professional development opportunities are offered, the more likely is a more comprehensive implementation of sustainability curricula.

The Role of Integration of Sustainability across Education, Research, Campus Operations, and Outreach

Implementing innovations in a curriculum is influenced by overall strategies of the HEI. Synergies between teaching and research (Griffiths, 2004), learning and community partnerships (Buys & Bursnall, 2007), and the campus used as a living lab (J. Evans et al., 2015) are examples that apply to all disciplines.

Accordingly, the sustainability strategy of an HEI influences curriculum changes (Sterling, 2004). Implementation of sustainability curricula is associated with efforts of integrating sustainability into research, campus operations, and outreach activities (Gramatakos & Lavau, 2019; Yarime et al., 2012). For example, outreach activities with businesses, communities, or NGOs can advance implementing sustainability curricula because these partnerships call for students being able to engage with a variety of real-world projects to co-develop sustainable solutions (Trencher et al., 2014; Wiek et al., 2014). From this review, we derive:

Assumption 2 - The more sustainability is integrated in research, campus operations, and outreach, the more likely is a more comprehensive implementation of sustainability curricula.

The Role of Leadership

Leadership strongly mediates to what extent curriculum changes in general take place (Fumasoli & Stensaker, 2013). Leadership for implementing sustainability curricula can unfold in different settings. Internally, the HEI's vision, commitment, strategic planning, and communication can all

absorb sustainability on the leadership level (Bauer et al., 2018), which then can demand or allow for implementing sustainability curricula. However, other stakeholders (e.g., faculty as sustainability champions) are essential for a successful implementation as top-down and bottom-up initiatives often go hand-in-hand (Ferrer-Balas et al., 2008; Ralph & Stubbs, 2014). From this review, we derive:

Assumption 3 - The more leadership support is offered, the more likely is a more comprehensive implementation of sustainability curricula.

The Role of Faculty and Students

Curriculum changes require active involvement of all internal stakeholders - not just to overcome apprehension, but to capitalize on collective knowledge and experience (Turan et al., 2016). Faculty's perception of sustainability, links to their discipline, resistance to change, and take on academic freedom are important influencing factors (Cotton et al., 2009; Reid & Petocz, 2006). Complementarily, students' attitude for sustainability topics (Borges, 2019) and their demand puts pressure on universities to develop sustainability curricula early in the implementation process while their acceptance and choices are vital to advance the implementation and establish sustainability courses and programs in the long term (Barth, 2013). From this review, we derive:

Assumption 4 - The more internal stakeholders (faculty, students) are actively involved, the more likely is a more comprehensive implementation of sustainability curricula.

The Role of Sustainability Champions

Organizational changes and curriculum innovations in general require early adopters or champions (Brint et al., 2011). Sustainability champions, in this context, can be described as early adopters that pioneer implementation of sustainability curricula (Ferrer-Balas et al., 2008; Purcell et al., 2019). These actors are vital for getting the implementation process off the ground by putting effort and time into it without any formal incentives. They can be individuals or (small) collectives from any stakeholder group: students who set up their own sustainability course; a faculty member who develops a sustainability certificate program; or a new university president who brings a strong sustainability vision to an HEI. Most often, individual faculty members pioneer sustainability education at their HEI (Barth, 2015). From this review, we derive:

Assumption 5 - The more the process is pioneered by sustainability champions, the more likely is a more comprehensive implementation of sustainability curricula.

The Role of External Stakeholders

State and federal laws and public funding determines the extent to which implementation of curriculum change is specified or supported. Furthermore, the call of employers and professional associations for employability and new competencies like the need for sustainability skills influence

curriculum changes. Also, recognition of sustainability by society at large can lead to a call for new programs. Finally, NGOs can act as supporting stakeholders, too. These influences have been investigated for general organizational change in higher education (Gornitzka, 1999; Teichler, 1999; Välimaa & Hoffman, 2008), and in several case studies on sustainability curriculum implementation (Ferrer-Balas et al., 2008; Juárez-Nájera et al., 2006). From this review, we derive:

Assumption 6 - The more external stakeholders are actively involved, the more likely is a more comprehensive implementation of sustainability curricula.

5.3.3 Research Design

We analyze case studies on sustainability curricula implementation processes around the globe through the case survey method, a meta-analytical technique that allows "to systematically and rigorously synthesize previous case-based research [...], allowing for a much wider generalization than from single case" (Newig & Fritsch, 2009).

The study was conducted in five steps:

1. Sampling: A case is defined as a sustainability curricula implementation process in a higher education institution. The sample includes case studies from different cultural contexts, employing different concepts of sustainability and of ESD. Case studies were selected based on the following criteria: Case studies of higher education institutions that describe the implementation process of sustainability curricula (including supporting and hindering factors) to some extent, published in English, in peer-reviewed journals and books, between 1990 and 2017[16]. Case studies were identified through the review of abstracts: (1) from the six journals most relevant for HESD; (2) from three databases (Web of Science, Scopus, ERIC) using the search string (TITLE-ABS-KEY ((„higher education" OR universit* OR college OR "tertiary education" OR "post-secondary education" OR facult*) AND (curricul* OR course OR program OR degree) AND ("education for sustainable development" OR "education for sustainability" OR "sustainability education")); (3) and from two relevant book series. The case sample was reviewed by ten experts worldwide. Excluding duplicates, the case universe included 230 case studies and 270 publications. For this study, we selected 133 case studies in which at least one publication *focused* (more than a paragraph) on the implementation process of sustainability curricula (see Table 10.1 in the Appendix No.2, Section 10.2 for a full list of the sample). Information from the respective websites of the HEIs supplemented the dataset. Full description of the study design and the sample can be found in supplementary materials (Weiss & Barth, 2019, 2020a, 2020b, 2020c). The sample is structured as follows (Figure 5.5): 30% of cases come from the U.S. or from Germany, 23% from Asia and fewer cases from Australia and Oceania, Latin America and the Caribbean, and Africa. Most HEIs are medium-sized (41%) or large (31%), with 75% offering a diversity of disciplines (humanities, social sciences, natural sciences, life sciences,

[16] Printed incorrectly in the original published article as 2018.

engineering), and 32% with a sustainability faculty/department/center/chair. 16% cases were at the redesign level, 56% used the build-in approach, and 27% the bolt-on approach. Only 59% of all case studies provide empirical data. The number of publications that constitute a case study varied from 1 (63%) to 2 (20%) and more (17%) with 11 publications as the highest input. 59% of case refer to implementation in curricula across the university (general studies approach), the remaining cases refer to implementation in curricula at a department or in an individual curriculum.

2. *Coding scheme development*: A coding scheme with 111 standardized variables and detailed definition, operationalization, and measurement was designed to translate qualitative data from the case studies into quantitative data (Weiss & Barth, 2020c). The coding scheme is based on previous research on drivers and barriers associated with sustainability curriculum change, complemented with insights from the case studies.

Variables were predominantly classified as: (a) barrier (lack of/weak), (b) medium (described, but with unclear/ambivalent impact), (c) driver (high/strong), (d) other (if no category matched the description), or (e) not described (missing information). To rate the variable *sustainability curricula implementation*, we used the 4-item scale presented above (Sterling & Thomas, 2006).

3. Case coding: A database of quantitative data and a supplementary factsheet providing in-depth qualitative data for each case were produced. Coding was conducted by 5 trained coders using a protocol, with inter-rater agreement of 94% tested for 10 % of the cases.

4. Cross-case analysis: We analyzed the quantitative data by performing frequency analysis to examine which drivers and barriers are described most often. Detailed statistics for all 111 variables can be found in (Weiss & Barth, 2020a).

5. *Testing assumptions from the literature*: The assumptions were tested based on Pearson's chi-square tests with a sample of 132 case studies (1 case was excluded as it comprised an own category with too little comparable data). Additionally, standardized residuals provide information which cells contribute to a significant chi-square value (if the cell is beyond +/- 2, then the cell can be considered a major contributor) (Sharpe, 2015). To indicate the strength of the association, Cramer's V was used (> 0.3 is generally considered a strong association). Thereby, Fisher's exact test (Howell, 2012) and Monte Carlo simulation (Larntz, 1978) were used to take into account fewer frequencies for some cell sizes (Fienberg, 1979). Descriptive frequency plots of all variables that went into the assumptions are included in the Appendix (Figure 10.1, Appendix No. 10.1).

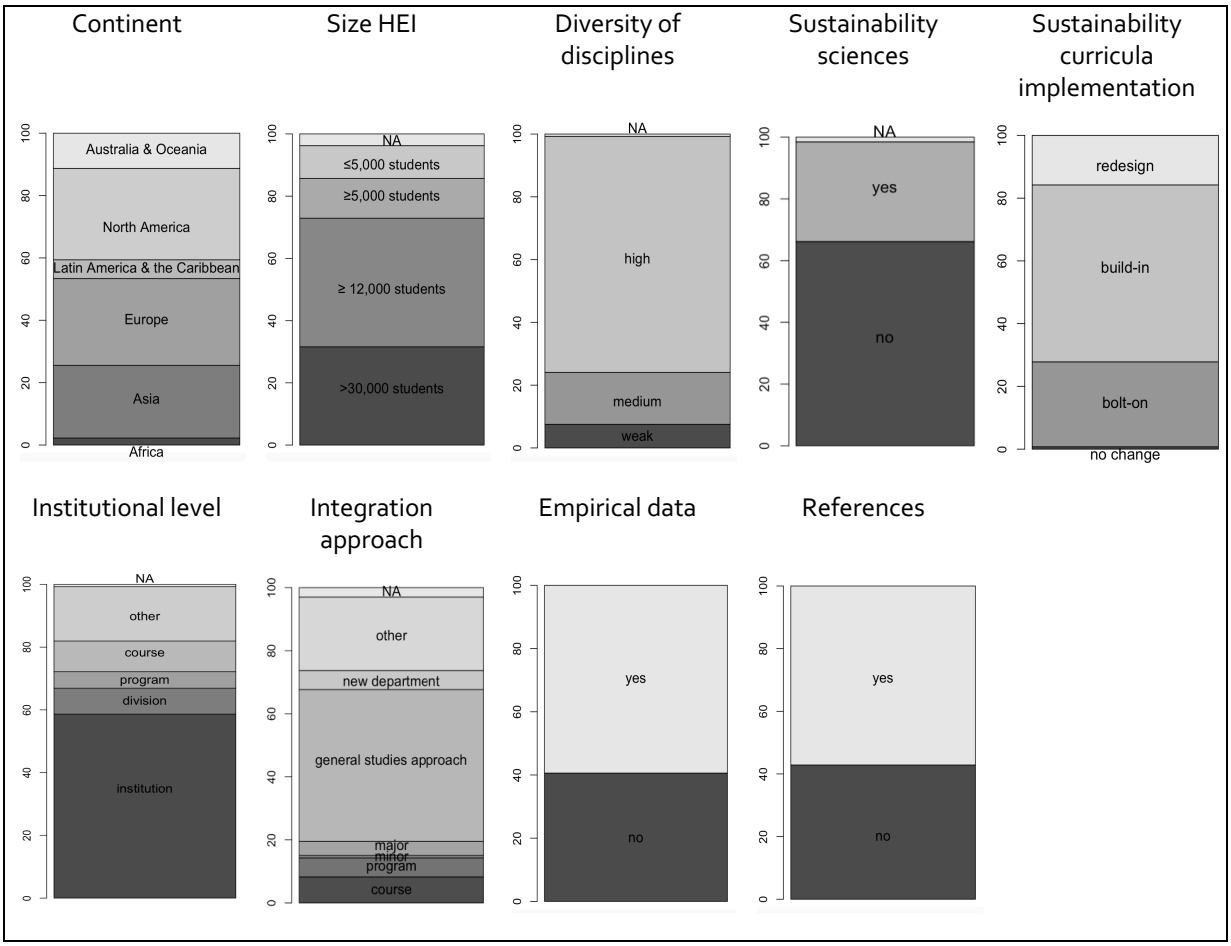


Figure 5.5 Sample description

Note. N = 133 case studies; y-axis shows count in percent.

5.3.4 Findings

Most common Drivers and Barriers of the Implementation

The most common drivers and barriers are listed in Figure 5.6, where strong coordination (63 cases = 47%) features as the most common driver, and a lack of interdisciplinary competence of faculty, (39 cases = 29%) as the most common barrier. Some of the top-10 drivers and barriers are directly corresponding, which emphasizes their importance for the implementation process. For example, in 33% of cases, the HEI's vision including sustainability fostered the implementation process, while a lack of sustainability in the HEI's vision was a barrier in 28% of cases. Similarly, strong leadership in sustainability education was a driver in 34% of cases, while weak leadership was a barrier in 10% of cases.

Other common drivers are: a strategic plan for implementation, a communication strategy to reach various stakeholders, involvement of internal and external stakeholders like the government and sustainability champions, and a window of opportunity.

Other common barriers are: the lack of incentives to engage faculty in sustainability curricula development; the organizational structure of the HEI (bureaucracy, guidelines, etc.); the structure of curricula which inhibited introduction of sustainability topics; lack of time and personnel; and a lack of collaboration within the institution to share resources and knowledge.

Figure 5.6 Most common drivers and barriers for implementing sustainability curricula at HEIs

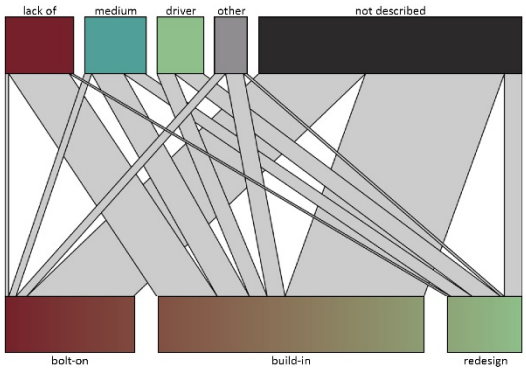
Note. N = 133 case studies; values indicate frequency of cases identifying driver/barrier.

Alignment of Assumptions on Drivers and Barriers from Literature vs. this Meta-study

Assumption 1 - The more incentives and professional development opportunities are offered, the more likely is a more comprehensive implementation of sustainability curricula.

To test for the assumed linkage between support and the level of sustainability curricula implementation, we ran two separate chi-square tests (incentives and professional development opportunities). The two variables that operationalize support show an overall significant linkage (Fisher's $p<0.001$) based on a significance level of 0.05 (this applies to all of the following hypotheses) with a rather strong association based on Cramer's V (for detailed statistics please see Figure 5.7).

Incentives

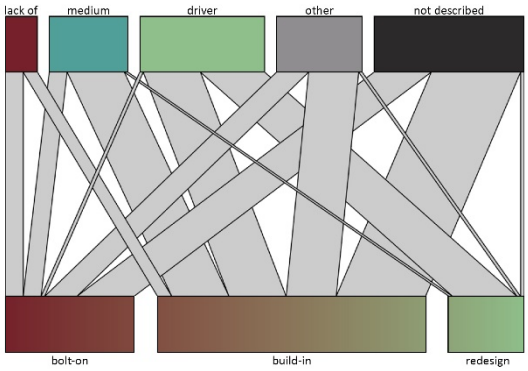


Level of sustainability curricula implementation

	bolt-on	build-in	redesign
lack of (barrier)	1, 5.18, -1.84	17, 10.79, 1.89	1, 3.02, -1.16
medium/ differing	2, 4.64, -1.22	9, 9.66, -.21	6, 2.70, 2*
yes (driver)	0, 3.55, -1.88	5, 7.39, -.88	8, 2.07, 4.12*
other	3, 2.45, .35	5, 5.11 -.05	1, 1.43, -.36
not described	30, 20.18, 2.19*	39, 42.04 -.47	5, 11.77 -1.98*

X^2=44.33, Fisher's p=1.28e-06 Cramer's V=0.4

Professional development opportunities



Level of sustainability curricula implementation

	bolt-on	build-in	redesign
lack of (barrier)	5, 2.45, 1.62	4, 5.11, -.49	0, 1.43, -1.2
medium/ differing	5, 6, -.41	16, 12, .99	1, 3.5, -1.34
yes (driver)	1, 9.54, -2.77*	16, 19.89, -0.87	18, 5.57, 5.27*
other	9, 6.54, .96	14, 13.64, .1	1, 3.82, -1.44
not described	16, 11.45, 1.34	25, 23.86, .23	1, 6.68, -2.2*

X^2= 53.12, Fisher's p=2.35e-08 Cramer's V=0.45

Figure 5.7 Linkages between support and sustainability curricula implementation in HEIs

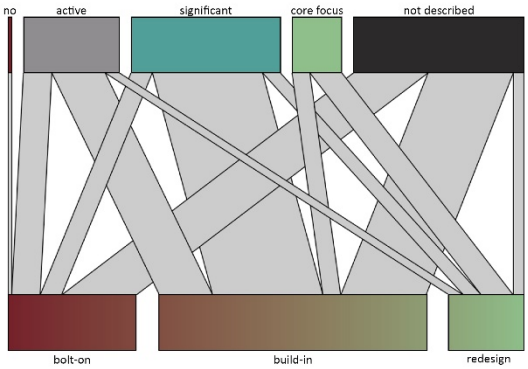
Note. N = 132 case studies; calculations are based on Pearson's Chi-squared test with simulated p-value (based on 2000 replicates); the values in each cell depict the count, the expected values, and standardized residuals; *significant at +/- 1.96.

If support was in place significantly more cases than expected comprehensively implemented sustainability curricula. Nearly 70% of all cases with curriculum redesign had incentives in place, whereas just 5% of the cases with a bolt-on approach had incentives in place. Over 90% of all cases with full redesign offered professional development opportunities (85% described it as a driver), whereas only 3% of the cases with a bolt-on approach provided such offerings. Based on this data, we confirm assumption 1 (We are aware that a chi-square test cannot indicate a direction of correlation. However, as barriers and drivers are described, and complementary qualitative data underpin the direction, this link seems both logical and supported by evidence. This also applies to all of the following hypotheses).

Assumption 2 - The more sustainability is integrated in research, campus operations, and outreach, the more likely is a more comprehensive implementation of sustainability curricula.

To test for the assumed linkage, we ran four separate chi-square tests, which show significant linkages (research, campus operations, synergies: Fisher's p<0.001; outreach activities: Fisher's p<0.05) with a rather strong association (except for outreach activities) based on Cramer's V (for detailed statistics please see Figure 5.8).

Integration with sustainability research

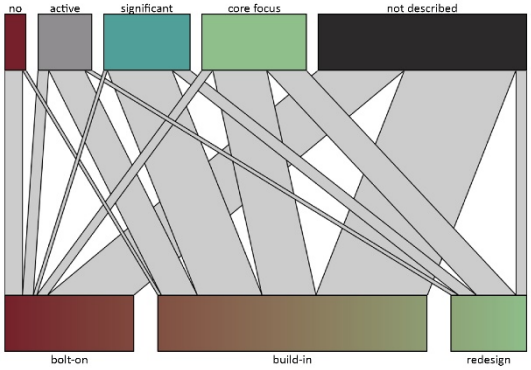


Level of sustainability curricula implementation

	bolt-on	build-in	redesign
no	1, .27, 1.39	0, .57, -.754	0, .16, -.4
active	8, 7.36, .23	15, 15.34, -.09	4, 4.29, -.14
significant	6, 11.45, -1.61	31, 23.86, 1.46	5, 6.68, -.65
core focus	0, 3.82, -1.95	5, 7.95, -1.05	9, 2.23, 4.54*
not described	21, 13.1, 2.19*	24, 27.27, -.63	3, 7.64, -1.68

X^2=41.40, Fisher's p=8.55e-06 Cramer's V=0.4

Integration with campus sustainability

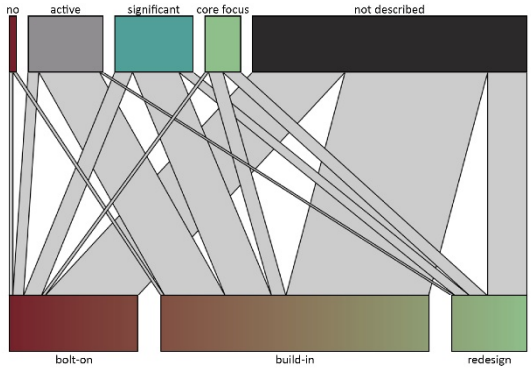


Level of sustainability curricula implementation

	bolt-on	build-in	redesign
no	5, 1.64, 2.63*	1, 3.41, -1.30	0, .95, -.98
active	3, 4.09, -.54	10, 8.52, .51	2, 2.39, -.25
significant	1, 6.54, -2.17*	18, 13.64, 1.18	5, 3.82 .60
core focus	3, 7.91, -1.75	15, 16.48, -.36	11, 4.61, 2.97*
not described	24, 5.82, 2.06*	31, 32.95, -.34	3, 9.23, -2.05*

X^2= 37.21, Fisher's p=7.38e-06 Cramer's V=0.37

Integration with sustainability outreach activities

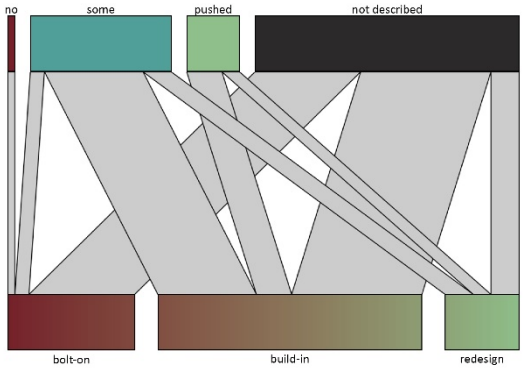


Level of sustainability curricula implementation

	bolt-on	build-in	redesign
no	1, .54, 0.61	1, 1.14, -.13	0, .32, -.56
active	3, 5.73, -1.14	17, 11.93, 1.47	1, 3.34, -1.28
significant	5, 6, -.41	13, 12.5, .14	4, 3.5, .27
core focus	1, 2.73, -1.05	4, 5.68, -.71	5, 1.59, 2.70*
not described	26, 21, 1.09	40, 43.75, -.57	11, 12.25, -.36

X^2= 16.6, Fisher's p=0.04 Cramer's V=0.25

Integration with synergies among the former



Level of sustainability curricula implementation

	bolt-on	build-in	redesign
no	2, .54, 1.97*	0, 1.14, -1.07	0, .32, -.56
some	4, 10.91, -2.09*	28, 22.73, 1.11	8, 6.36, .65
pushed	0, 4.09, -2.02*	10, 8.52, .51	5, 2.39, 1.69
not described	30, .45, 2.11*	37, 42.61, -.86	8, 11.93, -1.14

X^2= 25.05, Fisher's p=7.65e-05 Cramer's V=0.31

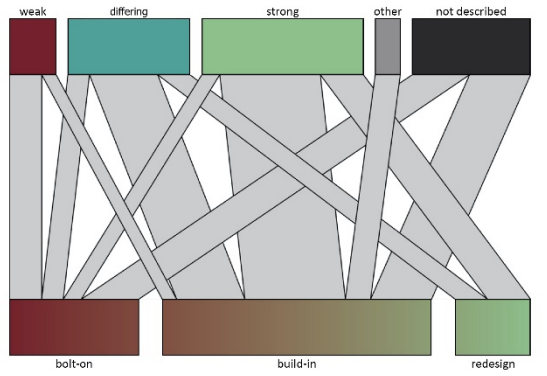
Figure 5.8 Linkages between the integration of sustainability in research, campus operations, outreach, plus synergies, and sustainability curricula implementation in HEIs

Note. N = 132 case studies; calculations are based on Pearson's Chi-squared test with simulated p-value (based on 2000 replicates); the values in each cell depict the count, the expected values, and standardized residuals; *significant at +/- 1.96.

If sustainability is implemented as a core focus in research, campus operations, and outreach activities significantly more cases than expected fully implemented sustainability curricula (redesign). In addition, if sustainability synergies between these areas were seized, significantly fewer cases than expected showed a low level of sustainability curricula implementation; and if no synergies were seized, more cases than expected had a bolt-on approach. Based on this data, we confirm assumption 2.

Assumption 3 - The more leadership support is offered, the more likely is a more comprehensive implementation of sustainability curricula.

The chi-square test shows an overall significant linkage between the level of leadership and the type of sustainability curricula implementation (Fisher's p<0.001) with a rather strong association based on Cramer's V (for detailed statistics please see Figure 5.9).



	bolt-on	build-in	redesign
weak	9, 3.54, 2.9*	4, 7.39, -1.25	0, 2.07, -1.44
differing	6, 9.27, -1.07	19, 19.32, -.07	9, 5.41, 1.54
strong	5, 12.27, -2.08*	28, 25.57, .48	12, 7.16, 1.81
other	0, 1.91, -1.38	7, 3.98, 1.52	0, 1.11, -1.05
not described	16, 9, 2.33*	17, 18.75, -.40	0, 5.25, -2.291*

X^2= 39.55, Fisher's p=07.65e-05, Cramer's V=0.39

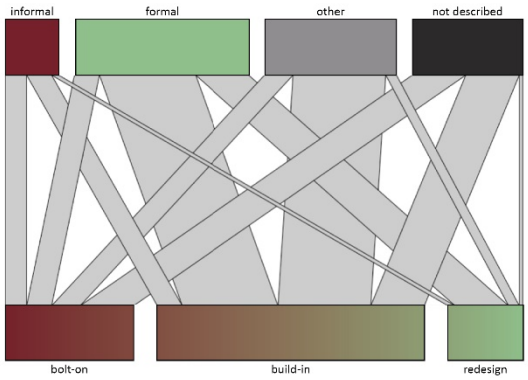
Figure 5.9 Linkage between leadership and sustainability curricula implementation in HEIs

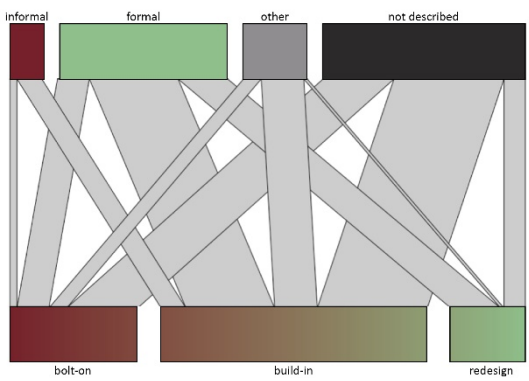
Note. N = 132 case studies; calculations are based on Pearson's Chi-squared test with simulated p-value (based on 2000 replicates); the values in each cell depict the count, the expected values, and standardized residuals; *significant at +/- 1.96.

There is a significant effect that no leadership is associated with a low-level ("bolt-on") of sustainability curricula implementation. Of all cases with curriculum redesign, 57% describe strong leadership (e.g., vision, strategic planning, incentives, coordination), and 43% describe ambivalent leadership (e.g., changing priorities, vision but no strategy). The majority of bolt-on cases do not describe leadership (44%) or mention the lack thereof (25%). Based on this data, we confirm assumption 3.

Assumption 4 - The more internal stakeholders (faculty, students) are actively involved, the more likely is a more comprehensive implementation of sustainability curricula.

To test for the assumed linkage, we ran two separate chi-square tests (*involvement of faculty* and *involvement of students*), which show an overall significant linkage for the involvement of faculty (Fisher's p<0.001), but not for the involvement of students (Fisher's p=0.07). For both, the strength of the association is rather weak based on Cramer's V (for detailed statistics please see Figure 5.10). However, the standardized residuals indicate a significant linkage between the *formal* involvement (university-led) of students during the sustainability curricula implementation process and full redesign. This also hold true for the formal involvement of faculty.





	bolt-on	build-in	redesign
formal	7, 13.36, -1.74	27, 27.84, -0.16	15, 7.79, 2.58*
informal	6, 4.09, .94	7, 8.52, -.52	2, 2.39, -.25
other	8, 10.09, -.66	26, 21.02, 1.09	3, 5.89, -1.19
not described	15, 8.45, 2.25*	15, 17.61, -.62	1, 4.93, -1.77

X^2= 22.56, Fisher's p=0.001, Cramer's V=0.29

	bolt-on	build-in	redesign
formal	9, 13.09, -1.131	25, 27.27, -.43	14, 7.64, 2.30*
informal	2, 2.45, -.29	7, 5.11, .83	0, 1.43, -1.2
other	5, 4.91, .04	12, 10.23, .55	1, 2.86, -1.1
not described	20, 15.54, 1.13	31, 32.39, -.24	6, 9.07, -1.02

X^2= 12.88, Fisher's p=0.07, Cramer's V=0.22

Figure 5.10 Linkage between involvement of internal stakeholders (faculty, students) and sustainability curricula implementation in HEIs

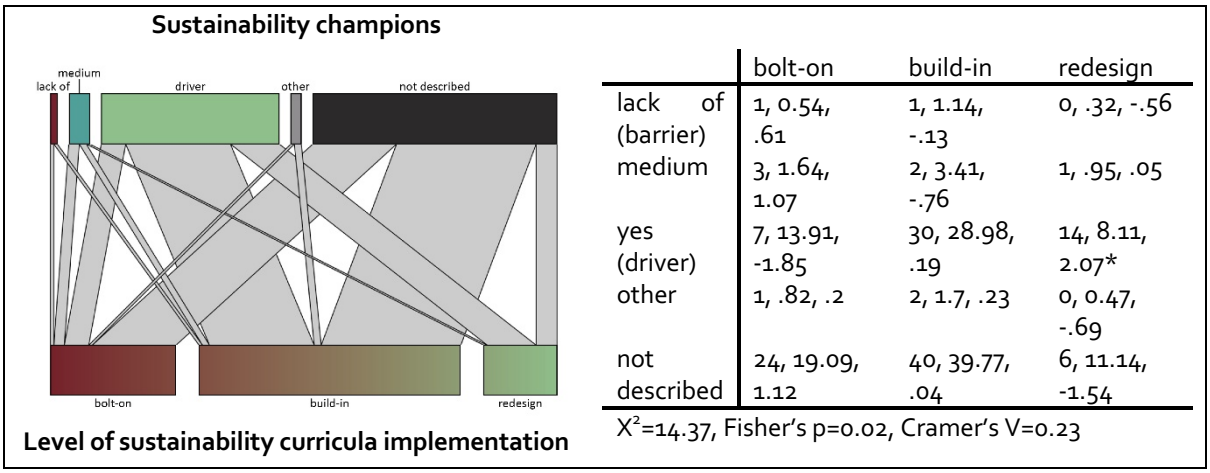
Note. N = 132 case studies; calculations are based on Pearson's Chi-squared test with simulated p-value (based on 2000 replicates); the values in each cell depict the count, the expected values, and standardized residuals; *significant at +/- 1.96.

Ca. 67% of all cases with curriculum redesign, 33% of all build-in cases, and nearly 25% of all bolt-on cases describe a formal involvement of students. A formal involvement of faculty was described in 70% of cases with full redesign, 36% of all build-in cases, and ca 20% of all bolt-on cases. If there only was informal (based on personal initiative) involvement of faculty, it was often linked with a lower level of sustainability curricula implementation ("bolt-on": 40%, "build-in": 47%). Based on this data, we *partially* confirm assumption 4 for the involvement of faculty, but not for the involvement of

students. However, there is supportive evidence for the linkage between *formal* involvement of students and a high level of sustainability curricula implementation.

Assumption 5 - The more the process is pioneered by sustainability champions, the more likely is a more comprehensive implementation of sustainability curricula.

The chi-square test shows an overall significant linkage between sustainability champions and the level of sustainability curricula implementation (Fisher's p<0.05) (for detailed statistics please see Figure 5.11). Based on the standardized residuals, a significant linkage exists between cases of full redesign and sustainability champions. In ca. 67% of cases with curriculum redesign, 40% of build-in cases, and ca. 20% of bolt-on cases, sustainability champions figured as drivers. Based on this data, we confirm assumption 5.



	bolt-on	build-in	redesign
lack of (barrier)	1, 0.54, .61	1, 1.14, -.13	0, .32, -.56
medium	3, 1.64, 1.07	2, 3.41, -.76	1, .95, .05
yes (driver)	7, 13.91, -1.85	30, 28.98, .19	14, 8.11, 2.07*
other	1, .82, .2	2, 1.7, .23	0, 0.47, -.69
not described	24, 19.09, 1.12	40, 39.77, .04	6, 11.14, -1.54

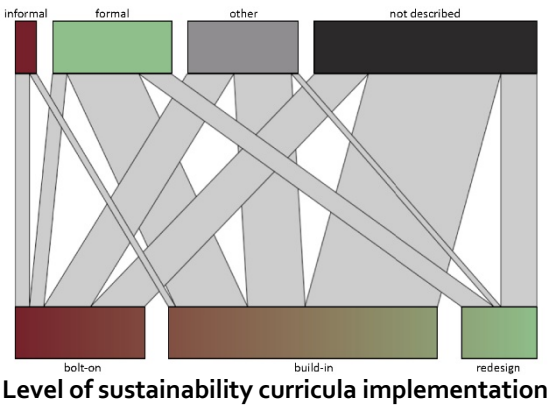
X^2=14.37, Fisher's p=0.02, Cramer's V=0.23

Figure 5.11 Linkage between sustainability champions and sustainability curricula implementation in HEIs

Note. N = 132 case studies; calculations are based on Pearson's Chi-squared test with simulated p-value (based on 2000 replicates); the values in each cell depict the count, the expected values, and standardized residuals; *significant at +/- 1.96.

Assumption 6 - The more external stakeholders are actively involved, the more likely is a more comprehensive implementation of sustainability curricula

The chi-square test shows an overall significant linkage between involvement of external stakeholders and level of sustainability curricula implementation (Fisher's p<0.05) (for detailed statistics please see Figure 5.12). In ca. 43% of cases with full redesign, 27% of build-in cases, and 11% of bolt-on cases, external stakeholders were formally (university-led) involved. Based on this data, we confirm assumption 6.



	bolt-on	build-in	redesign
formal	4, 9, -1.67	20, 18.75, .29	9, 5.25, 1.64
informal	4, 1.64, 1.85	2, 3.41, -.76	0, .95, -.98
other	13, 8.45, 1.56	16, 17.61, -.38	2, 4.93, -1.32
not described	15, 16.91, -.46	37, 35.23, .3	10, 9.86, .04

X^2=15.13, Fisher's p=0.02, Cramer's V=0.24

Figure 5.12 Linkage between involvement of external stakeholders and sustainability curricula implementation in HEIs

Note. N = 132 case studies; calculations are based on Pearson's Chi-squared test with simulated p-value (based on 2000 replicates); the values in each cell depict the count, the expected values, and standardized residuals; *significant at +/- 1.96.

5.3.5 Discussion

Positioning the Findings in the Literature

The goal of this study was to derive general insights on implementing sustainability curricula at HEIs through a meta-study of 133 case studies from around the globe, and to cross-check the findings against prominent assumptions from previous research (theoretical assumptions, small-N studies).

The findings confirm that the following factors (drivers) are linked to a high level of implementation (redesign): offering support; integrate sustainability in research, outreach, and campus operations; a supportive university leadership; the formal (university-led) involvement of faculty; the engagement of sustainability champions; and the formal involvement of external stakeholders. Formal involvement of students got partially confirmed as a driver. These findings go beyond previous research identifying drivers and barriers without linking them to implementation levels.

Support as driver. Our findings indicate that institutional support such as incentives and professional development positively influence the level of implementation, which is in line with findings from previous empirical studies. The relation between incentives and the level of implementation which Ferrer-Balas et al. (2008) identified in a comparative study on seven cases can be confirmed for the broader sample here. Other studies point to the lack of professional development support as main barrier (Ralph & Stubbs, 2014; Thomas & Nicita, 2002). As our results showed, professional development opportunities are implemented in 90% of all redesign cases, whereas only 3% of the bolt-on cases described such support. It seems that offering professional development opportunities is a key leverage point towards a redesign of curricula.

Sustainability integration as driver. We found supportive evidence for the link between the broad integration of sustainability in research, campus operations, outreach, plus synergies and a high level

of sustainability curricula implementation. Similar findings stem from previous small N comparative studies, in which integration among the former areas were found to be drivers (Purcell et al., 2019; Ralph & Stubbs, 2014; Shawe et al., 2019; Thomas & Nicita, 2002; Trencher et al., 2014). A majority of all redesign cases integrate campus sustainability (50%) or sustainability research (40%) at the core, whereas few of the bolt-on cases integrate campus sustainability (8%) and no sustainability research at the core. Outreach activities and synergies are not often described, but ca. 20% of redesign cases and almost none of bolt-on cases integrate these at the core. This suggests that especially the integration in campus operations and research can lead to a more comprehensive implementation (redesign). Based on a survey of 80 HEIs, Velazquez et al. (2006) propose a strategy how to achieve integration in all university areas.

Leadership as driver. We found that leadership through strategic plans, a vision and support provision advances sustainability curricula implementation, confirming earlier studies with smaller samples (Ferrer-Balas et al., 2008; Ralph & Stubbs, 2014). However, we acknowledge some interdependency in linking the redesign level with leadership support as we defined that redesign cases require leadership support. Nevertheless, we also found significant linkages in the other groups ("bolt-on", "build-in"), and curriculum redesign is also defined by other variables such as the institutional level or integration approach. Our findings suggest that a redesign of curricula is only possible if there is at least medium support of leadership. Ca. 57% of the redesign cases describe strong leadership support and 43% medium or ambivalent support. On the other hand, strong leadership support can, but does not have to lead to redesign. Ca 14% of bolt-on cases, 37% of build-in cases, and 57% redesign cases describe strong university leadership. De La Harpe and Thomas (2009) emphasize that solely mandating change from the top can turn into a barrier. We cannot confirm this assumption, but it seems that leadership support is more often an enabling condition than an active driver.

Faculty and students as drivers. Our study offers an empirical underpinning of the claim that involving faculty and student in the process leads to higher levels of sustainability curricula implementation (Barth, 2013; Purcell et al., 2019). Formal involvement of faculty and students is indeed linked with a high level of sustainability curricula implementation. Reid and Petocz (2006) point out that formal faculty involvement can prevent opposition which will be increasingly important when it comes to redesign. In such cases we see a significantly higher formal involvement of faculty (70%) and students (67%), whereas ca. 35% of build-in cases, and ca. 20% of the bolt-on cases formally involve these stakeholders. Apparently, a formal involvement like a university-wide visioning process is a driver for redesign. However, it could be further investigated which specific involvement methods work best as we included interviews, surveys, workshops, visioning process etc. as formal involvement.

Sustainability champions as drivers. Our findings confirm the claims based on theoretical contributions and small sample studies (De La Harpe & Thomas, 2009; Ferrer-Balas et al., 2008), in which champions were recognized as drivers of sustainability curriculum change. In 67% of all redesign cases, 40% of build-in cases, and 20% of bolt-on cases sustainability champions were a driver. These findings suggest that champions serve as drivers and often start the implementation

process by using their own scope ("bolt-on" and "build-in"), but also persuading leadership and faculty to reach redesign.

External stakeholders as drivers. We focused on involvement through partnerships with companies, municipalities, and NGOs, and did not account for the impact of laws, guidelines, or societal discourses, which function as external constructs rather than involvement. Only few previous empirical studies acknowledge external stakeholders as a driver (Ferrer-Balas et al., 2008; Juárez-Nájera et al., 2006). These studies often do not distinguish between formal and informal involvement. However, our data suggest that a distinction between a formal and informal involvement can differentiate between build-in implementation and redesign. Informal engagement of external stakeholders mostly achieves bolt-on (66%) or build-in (33%) implementation. A coordinated university-led involvement mostly leads to "build-in" (60%) or redesign (27%). Involvement of external stakeholders seems to be a driver in any of these cases. However, leadership support or a strategy for formally involving external stakeholders is more conducive to a more comprehensive implementation.

Other drivers and barriers. Coordination, communication, strategic plan, and vision were frequently mentioned internal drivers. This importance of a vision and a strategic plan is in line with previous findings from small-N case studies (De La Harpe & Thomas, 2009; Ferrer-Balas et al., 2008; Purcell et al., 2019; Ralph & Stubbs, 2014). The role of communication and coordination has also been identified in previous comparisons of few cases (De La Harpe & Thomas, 2009; Ferrer-Balas et al., 2008; Trechsel et al., 2018). In addition, a lack of formal settings such as sustainability committees was found to be a barrier (Ávila et al., 2017), while interdisciplinary spaces foster sustainability curricula implementation (Ferrer-Balas et al., 2008). This aligns with our finding that a lack of interdisciplinary spaces is a barrier. Additional external drivers we identified, namely, a window of opportunity and governmental influences have not been subjects of empirical studies, but rather theoretical reviews. However, Vargas et al. (2019) explore the role of policy integration frameworks on an organizational, national, and international level. Common barriers are lack of interdisciplinary competence (faculty), resources, curriculum flexibility, collaboration, and adequate organizational structure. Lack of collaboration is acknowledged in previous work (Adomßent et al., 2019; Trechsel et al., 2018), as is lack of adequate organizational structure, support from administrative staff, and resources (Ávila et al., 2017; De La Harpe & Thomas, 2009), which is in line with our results.

Combination of drivers and barriers. The majority of case studies we analyzed singled out specific drivers or barriers and very few case studies provide a more complete picture by linking multiple influencing factors to specific features of the implementation process. By testing the assumptions we see some nuances in implementing specific variables. In general, a higher or stronger implementation of a driver is linked with a higher level of sustainability curriculum implementation. However, full realization of one driver does not automatically lead to a high level of implementation. This can have several reasons: (a) mostly we are looking at snapshots of an implementation process and, for instance, it could be a starting point; (b) changing curricula is a highly complex process with certain

variables involved. This highlights that it takes several variables or drivers working together to steer sustainability curriculum change.

Limitations

Comparing secondary data poses various limitations as data vary in focus (different drivers and barriers), perspective (leadership, lecturer, sustainability champions, rarely students, or external researchers), and methodology, which make a comparison challenging. The analyzed case studies offered varying levels of details ranging from very few (Tamura et al., 2017) to full accounts of the sustainability curricula implementation (Holmberg et al., 2012). To run statistical analyses, we considered missing information as not relevant for the specific process. This is obviously not true, but comes with the limitation of analyzing secondary data (vs. primary data). Additionally, much of the case studies are self-reported with the bias leaning towards success stories - which distorts an accurate account of drivers and barriers. And third, published case studies overwhelmingly stem from particular countries and world regions - implying a blind side towards other (Weiss & Barth, 2019).

5.3.6 Conclusions

The findings suggest that implementing sustainability curricula in HEIs can benefit from a number of targeted actions ranging from integrating sustainability throughout the HEIs to involvement of all internal and external stakeholders. For comprehensive implementation (redesign), strong university leadership with a vision, a strategic plan, and broad coordination and communication are crucial. Limited resources can get offset through collaboration: internally, faculty and students can co-develop curricula; externally, networks with other HEIs, NGOs or companies can share knowledge on their experiences implementing sustainability topics in their teaching, but also on steering the implementation process in the whole HEI. The creation of interdisciplinary spaces supports such collaboration. Sustainability champions and faculty should be provided with support (e.g. professional development, time resources) to engage in implementing sustainability curricula. Windows of opportunity like a change in leadership, government changes, or societal challenges can be leveraged for starting implementation processes.

A standardized protocol for case studies on implementation processes would facilitate capturing more comparable details on implementation processes, and yielding a more comprehensive understanding of drivers and barriers. The analytical scheme applied here offers a starting point for such a protocol (Weiss & Barth, 2020c). Scholars suggest that organizational sustainability reporting ought to focus more on education, and should support planning for organizational change (Ceulemans et al., 2015; Madeira et al., 2011). This could serve as a basis for quality assessment of HEIs and for publishing complete case studies. In addition, intervention research could yield specifics about how drivers and barriers influence particular features of the implementation. Finally, research is needed on the *combination* of drivers and barriers and their influence on the implementation.

5.4 Study/Article 3: The Patterns of Curriculum Change Processes that embed Sustainability in Higher Education Institutions

Marie Weiss, Matthias Barth, Henrik von Wehrden

5.4.1 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

5.4.2 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 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 (Acevedo-Osorio et al., 2020; Yarime et al., 2012). 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 (De La Harpe & Thomas, 2009; Kotter, 1996; Verhulst & Lambrechts, 2015), transformational change (Eckel & 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 (Avery & Nordén, 2017; Gaugh & Scott, 2001; Hoover & Harder, 2015), 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 (Eckel et al., 1999; Hoover & Harder, 2015) 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 in order to achieve full implementation of sustainability curricula (Barth & Michelsen, 2013; Eckel et al., 1999; Hoover & Harder, 2015).

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 (Ávila et al., 2017; Lozano & Barreiro-Gen, 2019). 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 & 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:

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

5.4.3 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 Figure 5.13.

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 dataset (statistical or otherwise).
12. Report the study.

Figure 5.13 Applied steps of the case survey (adapted from Newig & Fritsch, 2009)

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 & 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 & 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 Table 10.1 in Appendix No. 2, Section 10.2). To transform the qualitative information into quantitative data, we developed an analytical scheme with 111 variables that included detailed operationalization (Weiss & 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", "build-in", and redesign (see Section 5.4.2). 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. 3 (Section 10.3), with detailed descriptions in Weiss and Barth (2020c) (Appendix No. 5, Section 10.5). 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.

5.4.4 Results

A short description of the case sample is shown in Figure 5.14 (for more details, see Weiss & Barth (2020a).

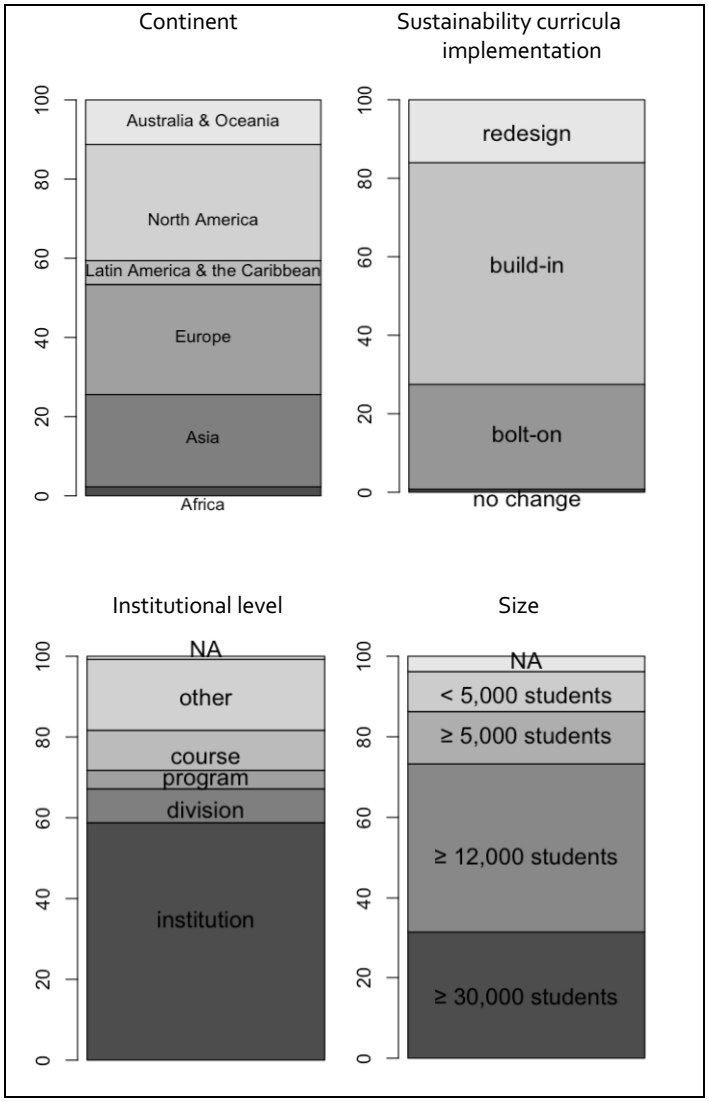


Figure 5.14 Sample description (N = 131 case studies; y-axis shows count in percent)

The cluster analysis reveals six specific patterns of sustainability curriculum implementation processes that can be found in HEIs (see Figure 5.15). 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.

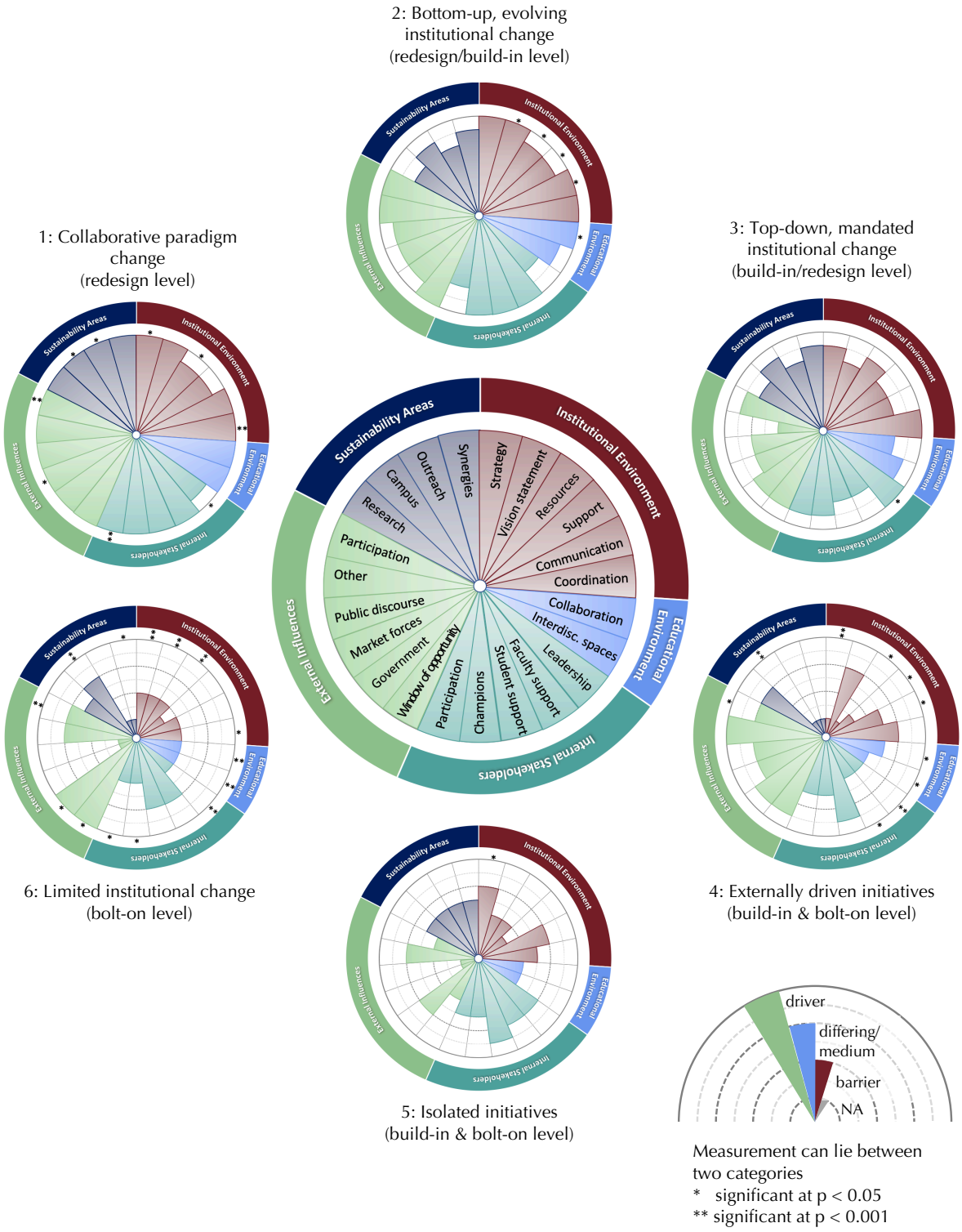


Figure 5.15 Six analytical patterns of sustainability curricula implementation in HEIs that emerge from a case survey analysis of 131 international case studies based on a Ward cluster analysis.

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 Appendix No. 4, Section 10.4. However, since we describe the clusters as analytical constructs in order to shed light on specific change processes, the distinction is analytical, and the boundaries between the patters are fluid.

Furthermore, in Figure 5.16, 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.

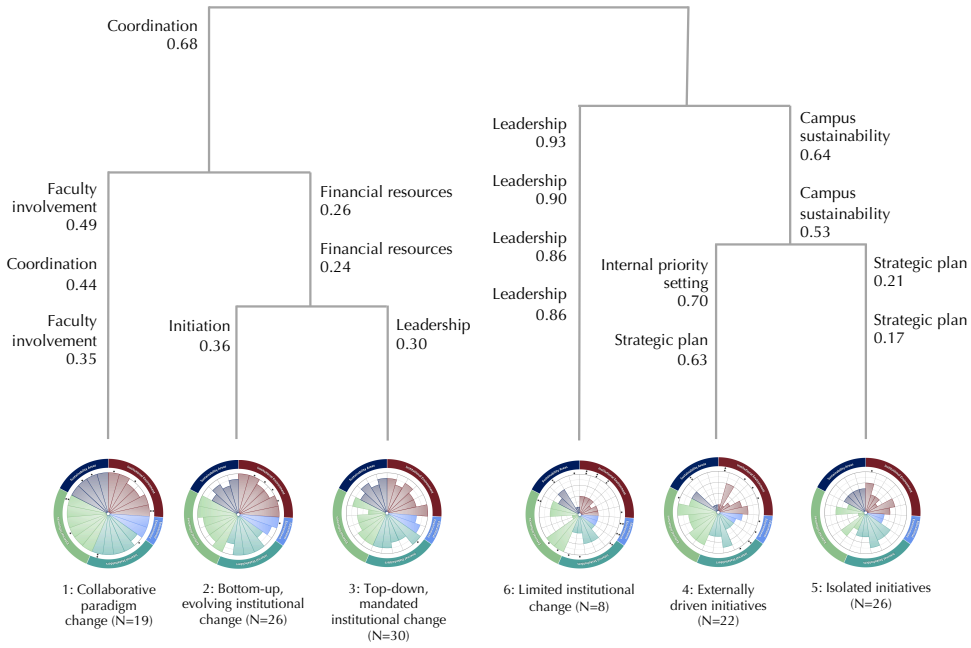


Figure 5.16 Dendrogram of distinct change processes used in implementing sustainability curricula. Based on a Ward cluster analysis of 131 international case studies.

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 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.

In most cases, this type of implementation is led either by a distributed leadership model or by a cross-faculty steering group in order 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.

In order 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 in order 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.

5.4.5 Discussion

By 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 Table 10.1 in the Appendix No. 2, Section 10.2). 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 it 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 & 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 in order 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 a 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 & 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 (Eckel et al., 1999; Fumasoli & Lepori, 2011). 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 & Harder, 2015). 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.

5.4.6 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 critical 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. In order 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., in order 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.

6 Synthesis & Implications: From drivers, Barriers, and patterns to transformation enablers

While the previous Chapter 5 presented the findings for each research article, this chapter provides a synthesis with the focus on the *interconnections* between the three individual research articles. To avoid redundancy, the specific sub-research questions (see Section 4.1) are not summarized again here as they are answered in the respective papers (see Chapter 5). A summary of these questions and their findings can be found in the overview of the articles and their respective abstracts (see Section 5.1).

The major research gap in the international discourse involves insufficient knowledge on the process(es) of *how* sustainability curricula are implemented and embedded in higher education institutions. This lack of knowledge applies particularly to the issue of generally valid implementation patterns or processes from which individual universities (and other stakeholders) can learn. Previous case studies have mostly examined individual processes in a descriptive way; therefore, the underlying research interest of this dissertation involves generalizable insights into drivers and barriers that influence more comprehensive sustainability curriculum change in HEIs and into how a better understanding of specific implementation patterns could enable sustainability curriculum change in HEIs.

Chronologically, the steps taken to answer the overarching research inquiry were as follows: In order to examine a larger pool of data, first, a global sample of individual studies was collected and bibliographically analyzed (Research Article 1, Section 5.2). In the second step, this sample was used to investigate which key factors promote or hinder the implementation processes of sustainability curricula at universities via a large pool of empirical data, which were then compared with theoretical assumptions about key factors (Research Article 2, Section 5.3). In the third step, the large case sample was used to investigate which different implementation patterns can be identified based on common influencing factors and a comparable level of achieved sustainability curriculum implementation (Research Article 3, Section 5.4).

Two main topics emerged across the three studies investigated in the research articles: (1) the enablers of successful sustainability curriculum change that lead to specific patterns of implementation processes and (2) the quality of the data – or how case studies can better learn from one another.

Since the process of implementing sustainability curricula always has several influencing factors that lead to a certain type of development, Research Article 3 – namely the 6 analyzed patterns as well as the characteristic variables that distinguish these patterns from one another (as elaborated in detail in Research Article 3, Section 5.4) – is synthesized and placed in context with insights from Research

Article 2, namely the individually analyzed key influencing factors (as elaborated in detail in Research Article 2, Section 5.3).

In the second synthesis step, conclusions are drawn regarding learning across cases and the quality of the data. These conclusions draw on Research Articles 1, 2, and 3 (Section 5.2-5.4).

The following elaborations are closely based on the results of the respective research articles. For the sake of transparency and in order to avoid self-plagiarism, it should be explicitly mentioned that certain text passages may be formulated similarly to passages in the respective papers; however, these passages contain novel connections.

6.1 Enablers of Successful Sustainability Curriculum Change

In order to highlight possible ways in which sustainability curricula can be deeply embedded in higher education institutions, first, the six identified implementation patterns are summarized. These patterns are not described in detail (for that, see Research Article 3, Section 5.4), but focus is placed on the significant variables that distinguish the different implementation processes from one another. Using this information, the variables that emerged as key influencing factors between the patterns are synthesized and matched with the results of the hypothesis testing and frequency analysis from Research Article 2 (for details, see Section 5.3).

The analysis – presented in Research Article 3 – found six specific implementation patterns of sustainability curricula in HEIs:

(1) Collaborative paradigm change, with the key identifiers being fruitful collaboration, 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 a high-level paradigm change of the HEI (leading to the redesign level).
(2) Bottom-up, evolving institutional change, with the key identifiers being bottom-up initiation and high levels of internal informal collaboration, and with presidential leadership support joining at a later stage in the implementation process, thereby leading to greater formalized support and collaboration (leading to the redesign- / build-in level).
(3) Top-down, mandated change, with the key identifiers being initiation and execution by presidential leadership and a lower sense of faculty ownership (leading to the build-in- / redesign level).
(4) Externally driven initiatives, with the key identifiers being weak internal support and planning and a strong external driver (leading to the build-in- & bolt-on levels).
(5) Isolated initiatives, with the key identifiers being the involvement of few stakeholders as well as weak coordination and cross-faculty collaboration (leading to the build-in- & bolt-on levels).

(6) Limited institutional change, with the key identifiers being the number of described barriers – that is, weak support of various stakeholder groups, loss of momentum, and the inability to establish long-lasting internal cultural change (leading to the bolt-on level).

In comparing and synthesizing the insights from the frequency analysis and hypothesis testing (described in Paper 2) and the cluster analysis (described in Paper 3), the following key influences emerged as enablers of more comprehensive sustainability curriculum implementation.

Involvement of internal & external stakeholders

The actions of various stakeholders form the core of implementation processes. Through their interests, motivations, power, powers of persuasion, and actions, these stakeholders can lead to the implementation of sustainability curricula.

- Several stakeholders with varying levels of decision-making power come into play to initiate sustainability curricula, as was shown in the cluster analysis, in which different implementation processes were found to have been initiated either by external stakeholders (via collaborations with other universities, (inter)national research networks, or local companies) or by internal stakeholders. Externally, governmental influences – such as new laws or guidelines – were particularly evident as key driving factors. Internally, students or individual sustainability champions from the faculty could demand sustainable teaching and implement it on a small scale (and could scale it up), or a new profile orientation could be decided on top-down. Additionally, windows of opportunity – such as a change in leadership or societal challenges – can function as a key driver that takes the implementation of sustainability curricula to the next level. Such opportunities and circumstances act as a lever for change and were evident in the cluster analysis as well as in the frequency analysis.
- When the implementation level is taken into account, it becomes clear that the deepest-rooted implementation (redesign) occurs when all internal and external stakeholders participate and collaborate. However, external stakeholders alone cannot bring about curriculum change on a large scale. Internal stakeholders have the greater power to decide on sustainability curricula. Leadership and internal priority setting were found to be important sources of influence in the cluster analysis and to serve as both key drivers and barriers in the frequency analysis, which was further supported by hypothesis testing. However, if additional internal stakeholders – such as students or faculty – are not involved, the level and quality of the implementation is limited. The role of stakeholders was reinforced by the hypotheses that were tested and the key drivers and barriers that were analyzed in Research Article 2, in which governmental influences and sustainability champions were mentioned as key drivers in the case studies. Hypothesis testing further confirmed that both the (planned) participation of faculty and students and activities that drive sustainability champions lead to a more comprehensive level of implementation. This finding also holds for the involvement of external stakeholders.

- Furthermore, mutually integrating sustainability topics into all university areas – such as education, research, campus, and outreach – is conducive to more comprehensive implementation of sustainability curricula. This finding was highlighted by the cluster analysis as well as through hypothesis testing.

The nature of collaborations among the various involved stakeholders

In order for the actions of the various stakeholders to lead to change, these stakeholders need to collaborate with one another, establish a strategy, share a common vision, implement this vision in a coordinated manner, and inform all other stakeholders about the status quo.

When establishing sustainability curricula, initiators need to *collaborate* with other stakeholders, which includes integrating initiatives from all university areas (education, research, campus operations, and outreach). Collaboration is important because implementing sustainability curricula is complex and requires resources and stamina. The frequency analysis from Research Article 2 revealed that key barriers include a lack of interdisciplinary competence in teaching sustainability topics and a lack of professional support and resources (including time). This finding is also supported by the hypothesis test, which revealed that professional support and incentives (e.g., extra time) are linked with more comprehensive sustainability curriculum implementation. Furthermore, missing collaboration is among the key barriers mentioned in the case studies (frequency analysis), but collaboration is also the driving factor behind the most-successful implementation pattern (collaborative paradigm change), as was revealed by the cluster analysis in Research Article 3. Additionally, this cluster analysis also found that external coalitions (e.g., research projects with other HEIs) can compensate (to a certain extent) for missing internal professional support. In summary, the various data demonstrate that it is important to share knowledge and resources through collaboration in order to fill a gap and/or to lead to synergies that enable a specific level of sustainability curriculum implementation to be reached that could not be reached without sharing knowledge and resources. The creation of interdisciplinary spaces can support such collaboration, as illustrated across the various clusters as well as in the frequency analysis from Research Article 2, in which these spaces were found to act as a key driver that supports curriculum change and as a key barrier to this change if they are missing. The limited nature of isolated initiatives is also illustrated by Cluster 5.

A *shared common vision* is particularly effective for successful cooperation and collaboration between various stakeholders. This shared vision resolves misunderstandings of what is meant by ESD, stimulates reflections on one's own understanding, enables a shared understanding to be developed, and thus leads to *ownership* by all stakeholders. This shared ownership is in turn reflected in motivation, stamina, and action. Not only are these linkages reflected in various patterns, but the central influencing factor of having a shared vision is also found among the most-frequently cited drivers and barriers.

Controlled *coordination* is essential for bringing together different actions and collaborators in a meaningful way. In the frequency analysis, coordination was described as the most-frequent driver

in the case studies. In coordination, some kind of steering committee, strategy, and monitoring as well as reflection on the usefulness of established organizational structures function as variables that are connected with more comprehensive implementation of sustainability curricula. These influences were also apparent in the cluster analysis.

A *communication* strategy that reaches all stakeholders is needed in order to inform these stakeholders about progress and planned steps and to promote exchange, discussion, and reflection, especially for reaching and sustaining a critical mass of supporters. If no formal communication channels or formats are established, informal communication (e.g., virtual communication) can compensate for both the missing formal communication and the missing professional support. Not only are these relationships evident from the case descriptions within the cluster analysis, but the frequency analysis also indicates that communication is a key driver.

The following Figure 6.1 provides an overview of the above described most significant influencing factors by outlining how the extent of these influencing factors lead to different levels of implementation as well as different implementation patterns.

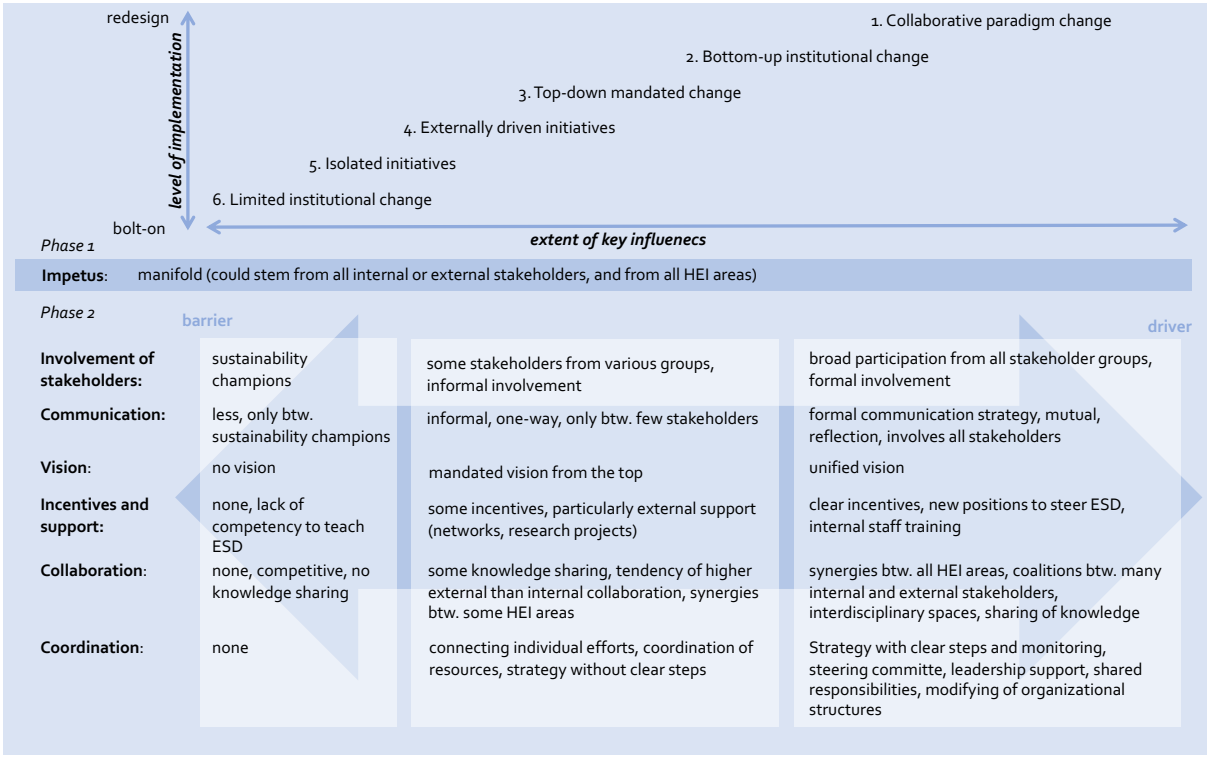


Figure 6.1 Enablers for a more comprehensive sustainability curriculum implementation process (N = 131-133 case studies; synthesis of the results from research article 2 & 3) (author's own elaboration)

During the course of the present study, new research emerged that could not be included in the discussion sections of the respective articles. Recent articles have analyzed the role of networks (Bohunovsky et al., 2020) and a whole-institution approach (Giesenbauer & Müller-Christ, 2020) and have placed special focus on items such as the interdependencies of culture and the functions of sustainability governance (Bauer et al., 2020), and successful staff training (Scherak & Rieckmann,

2020). Moreover, one comparative study on 13 Austrian HEIs focused on the interplay between certain variables and derived some insights from a timeline analysis (Bohunovsky et al., 2020). Insights from this study highlight the importance of internal and external alliances and networks, which is in line with the results of the present study and supports the identified patterns of implementation processes.

6.2 The Distribution and Quality of Case Studies: How to Enable Cases to Better Learn from One Another

In order to better understand the research landscape on the implementation processes of sustainability curricula in higher education institutions, the present study investigated where case studies occur, which countries they can be assigned to, which are the most cited, and other bibliographic factors. The detailed results are presented in Research Article 1 (see Section 5.2). To summarize the findings, the field of research on sustainability curriculum processes in HEIs is rapidly growing. Articles on the topic have been published in a scattered array of journals, thereby impeding the identification of relevant articles in the discourse and the ability to learn from them. Most cases come from North America, Europe, Asia, and Oceania, with underrepresented research in Africa, Latin America, and the Caribbean. A citation network analysis revealed which case studies cite others and are thereby likely to have learned from well-published strategies used by other HEIs. The "Western world" appears to be quite well connected, whereas other domains (including countries that are located next to one another and may share similar contextual factors) are not. This finding begged the question as to how cases learn from one another. The cluster analysis (described in Research Article 3) provided some additional answers to this question. Opportunities to truly learn from and support other HEIs in implementing ESD come mostly from (inter)national networks or research projects. Furthermore, some case studies described having actively searched for best practices both internationally and transnationally and also having searched for niches in which to implement study programs.

In preparing and conducting the meta-analysis as part of the present dissertation (Research Articles 2 & 3), first, a coding scheme had to be developed that would ensure the most-detailed mapping and description of the drivers of and barriers to the implementation process of sustainability curricula at universities. Through a theoretical review, it became clear that no analytical scheme yet existed that mapped a large number of possible operationalized influencing factors. To date, the discourse has tended to be characterized by lists of individual variables that do not include a specific operationalization that describes the level of influence. This finding can be interpreted as the first indication that individual case studies have no guideline to use when determining which variables should be included in a case description that other HEIs can learn from. Therefore, the coding scheme represented in Appendix No.5 (Section 10.5) and published as an open-access file is intended to support further research to that end. However, since transformation processes are highly complex, this coding scheme should be taken as a starting point since there is certainly potential for

improvement. Nevertheless, the coding scheme developed in the present study (also referred to as the "EFCA analytical scheme") is the very first comprehensive analytical tool for summarizing and operationalizing factors that could potentially influence the implementation process of HESD. The EFCA analytical scheme thus enables comparisons and learning between different case studies.

The analyses in Research Articles 2 & 3 reveal which variables have been reported well or poorly across case studies. The descriptive statistical report of all variables that are included in the case survey analysis (Appendix No. 6, Section 10.6) presents details as to how each variable is reported. In general, some variables are reported more thoroughly than others, which may be due to the fact that certain variables have not influenced the implementation process of sustainability curricula. Nevertheless, explicit information on both the process itself (stages, barriers, drivers, irrelevant variables, coping strategies) and the output of the process (the level of sustainability curriculum implementation) is often missing. An overview of how the variables are reported is provided in Figure 6.2. The mentioned variables are structured according to the EFCA analytical scheme and indicate whether more or less than 50% of the case sample reported on them.

In order to better enable HEIs to learn from one another in embedding HESD in the core of an institution, a good starting point would be to reflect thoroughly on the specific sustainability curriculum implementation processes and to document, report, and publish on them. The EFCA analytical scheme could thereby provide useful information to any form of analysis or reporting effort on HESD implementation. Furthermore, other collaborations and opportunities to discuss experiences should be sought, for example, through collaborative (international) research projects, the shared development of HESD study programs, or associations and networks.

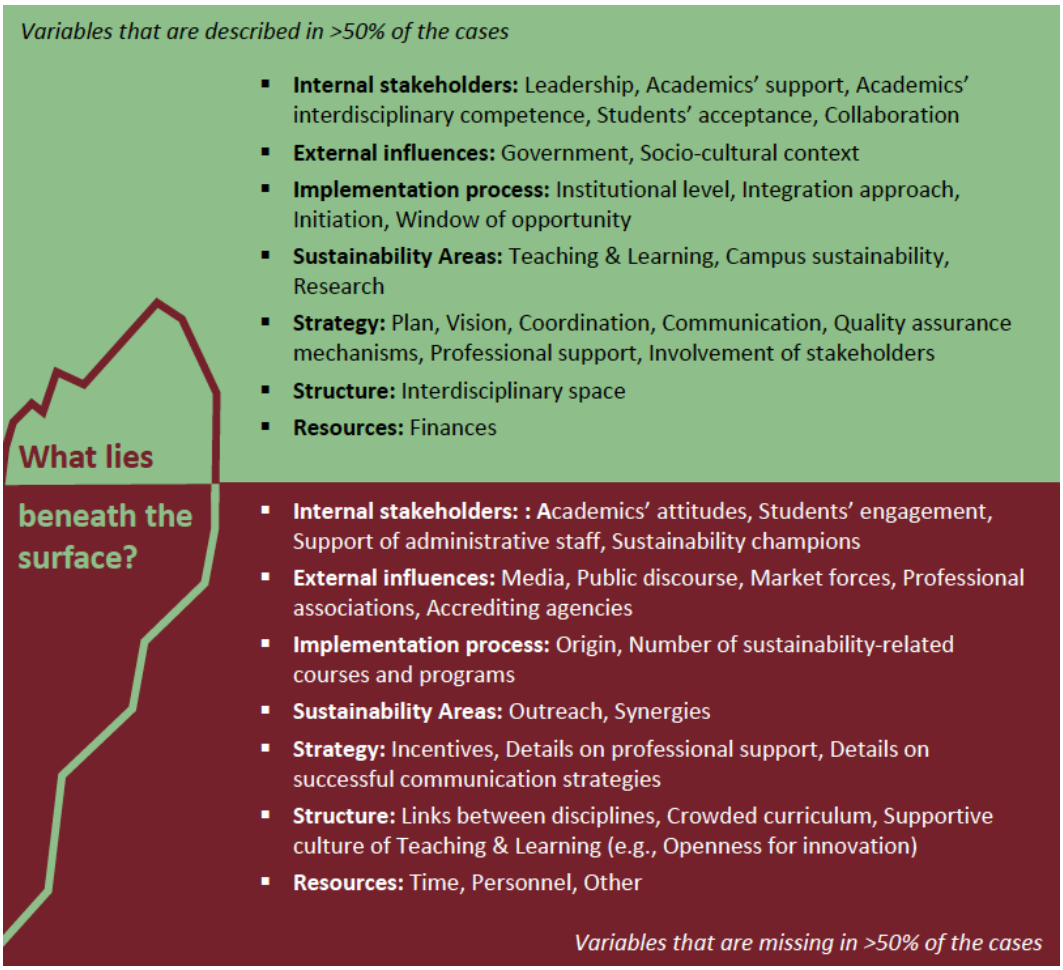


Figure 6.2 Poorly and well-described influencing variables in the case sample (N = 133 case studies) (author's own elaboration)

Part IV

Discussion, Conclusions & Contributions, & Future Research

7 Discussion of the Methodological Approach

The aim of the present study was to provide a complementary perspective on generalizable findings on the implementation processes of sustainability curricula in higher education institutions. Thanks to a comprehensive search strategy and the structured approach of the case survey method, this aim was largely reached. Nevertheless, the representativeness of the case sample should be critically examined in order to determine the generalizability of the findings.

It should first be noted that the search strategy deliberately only included peer-reviewed case studies in English that focus on ESD, and other concepts related to ESD were therefore not included. The English language was selected in order to make the studies analyzable by the raters. The bibliographic analysis revealed an imbalance between countries and continents as well as a dominance of Western authors. The consideration of further studies in other languages or documentation by students or NGOs that do not appear in peer-reviewed articles would change the case universe and possibly also the results. Furthermore, the bibliographic analysis revealed that texts on this topic are published in many different (inter)disciplinary journals, which are therefore highly scattered, and it is thus almost impossible to find every existing case study, even with a very sophisticated search strategy.

In order to compare data from different case studies, a coherent and empirically operable analytical scheme (that allows for transforming the qualitative data from the case studies into quantitative data) is crucial (Lucas, 1974). With respect to internal validity, several limitations require discussion. On the one hand, the specific coding scheme is critical for capturing the respective implementation processes as exactly as possible. As a coding scheme is a deductive procedure, it is possible for factors that are not covered by the variables to sometimes remain undiscovered. However, in order to cover all described influencing factors as thoroughly as possible, the coding scheme used in the present research was developed via several iterative steps both deductively and inductively (as described in Section 4.3 and in Appendix No. 5, Section 10.5). During the analysis, the use of the coding scheme and the statistical analyses demonstrated that certain constructs can be captured very well (internal validity) using the data provided by the primary sources. This finding is further supported by the inter-rater test (reliability and objectivity), which yielded an inter-rater agreement of 94% for 10% of the cases and thereby revealed that the constructs from the coding scheme were captured very well, independent of the rater.

On the other hand, the case studies vary in data quality and scope. Not all case studies provide information on all variables, which means that not all variables could be coded (i.e., they could not all provide relevant data for the analysis). The descriptive report contains an overview regarding which categories per variable were coded how often and how often no information was available for the variable (Appendix No. 6, Section 10.6). In order to deal with the missing data over a large sample, the missing information was treated as irrelevant, which is probably not true in actuality. This missing

information may have several causes, such as the lack of research on a case, different publication formats and HEI strategies for publishing on a sustainability curriculum implementation process, or different foci. Moreover, a bias could exist with regard to success stories such that obstacles and mistakes were excluded. In addition, tracking the transformation process toward sustainable development over several decades proved highly challenging. For some cases, an impression of only certain parts of the process could be gained. Nevertheless, the above-mentioned challenges cannot be avoided when analyzing secondary data.

Therefore, the database could be strengthened and the EFCA analytical scheme further developed by using other data types to verify and complement the coded variables, particularly for variables for which it was difficult to obtain data points. In so doing, primary data could be used to complement the data points of this study via the inclusion of surveys or interviews, and other secondary data – such as databases or documents from higher education associations that collect information on efforts regarding ESD – could be used (e.g., the database of the International Association of Universities, https://www.iau-hesd.net/). Furthermore, in-depth studies with several different types of HEIs could be conducted to advance the analytical scheme's ability to capture the constructs of interest via a discussion of the operationalization of the variables.

A further quality criterion that applies to conducting case surveys is the replicability of the study (Lucas, 1974). In order to fulfil this criterion, in addition to the actual publications of the results, the entire study process was well documented via case lists, the coding / analytical scheme, a descriptive report with additional background data, and supplementary material consisting – inter alia – of coding reports and raw data. This material can also be used by external researchers to obtain replicable results or to investigate other contexts and underrepresented cases.

Further reflections on the respective analytical methods used in the three studies described in Chapter 5 as well as a discussion of the respective results and their embeddedness in the scientific discourse can be found in the respective research articles.

8 Conclusions: Ways forward in implementing Sustainability Curricula in Higher Education

The purpose of this dissertation was to provide more-generalizable results on sustainability curriculum implementation processes. Using a broad case sample, the aim was to analyze key drivers and barriers, identify specific patterns, and derive insights for successfully (i.e., more comprehensively) implementing sustainability curricula in higher education institutions that are shared across different contexts.

To frame the aspects of this aim, the overarching research question was:

What generalizable drivers and barriers influence more comprehensive sustainability curriculum change in higher education institutions, and how could a better understanding of specific implementation patterns enable sustainability curriculum change in higher education institutions?

In a three-step approach, both this question and the research landscape in general were addressed by (a) analyzing the research landscape on sustainability curriculum implementation patterns and collecting a database of case studies from around the globe (N = 230), (b) analyzing key drivers and barriers on a larger empirical basis (n = 133 case studies), and (c) identifying sustainability curriculum implementation patterns on a larger empirical basis (n = 131 case studies).

In the following section, an outline is presented that details how the findings contribute to the specific research landscape, what the theoretical and methodological contributions are, and how practitioners can derive advantages from the research insights.

8.1 Research Contributions

The first major contribution of this dissertation is its mapping and description of the current research landscape of sustainability curriculum implementation processes, which offers at least three main insights:

(1) The collection and mapping of the (single and small-N comparative) case studies from around the globe offers a novel overview as to where research on sustainability curriculum implementation processes is happening and where blind spots still exist.

(2) The dissertation further provides insights into the general development trend based on a bibliographic analysis and thereby demonstrates that case studies on sustainability curriculum implementation processes are an emerging field of research with publications in a diverse array of interdisciplinary journals.

(3) Based on a citation network analysis, the "Western world" can be seen to be quite well connected, whereas other countries are not, indicating that sharing information between and learning from other cases is limited. This insight can help illuminate which HEIs or case studies we can still learn from and which we have actually learned from.

The second major contribution of this dissertation is its analysis of sustainability curriculum implementation processes based on a larger sample of case studies and its ability to overcome single-case-study narratives. The dissertation provides a database of (mostly single) case studies published between 1990 and 2017 under a Creative Commons license. This database offers a large empirical basis for further comparing, analyzing, and drawing more-generalizable insights. Two main analyses that draw on information from this database provide novel insights for better understanding sustainability curriculum implementation processes:

(1) Generalizable insights into key drivers and barriers that are shared in different contexts were identified. Through these insights, novel empirical evidence from 133 case studies was added to the research landscape, and at least two important new items were added to the existing research landscape on drivers and barriers:
    - A top-ten list of commonly described key drivers and barriers across different contexts was created.
    - An investigation was conducted into the connections between certain drivers and barriers at the level of sustainability curriculum implementation by testing theoretical hypotheses. New insights were gained in the research landscape, particularly via the analysis and operationalization of certain influences on the level of depth of HESD.

(2) This dissertation represents a first attempt to identify distinctive sustainability curriculum implementation patterns that are shared across the globe using evidence from 131 case studies.
    - Six distinct sustainability curricula implementation patterns were identified that lead to varying degrees of the level of depth of the implementation.
    - It is also one of the first attempts to focus on better understanding sustainability curriculum implementation processes by taking into account the various relationships between drivers and barriers, the attained level of curriculum change, and various phases of the implementation process. Future studies can build on these insights and further investigate these specific types of connections and processes.

8.2 Methodological Contributions

From a theoretical and methodological perspective, three main contributions of this dissertation can be derived:

(1) The present study is the first attempt to apply the case survey method to research inquiries in the field of HESD and reveals the opportunity and value of adding another type of data / perspective to the discourse. Moreover, this study offers a variety of documents that could guide further endeavors in applying the case survey method in research on HESD.

(2) The results of the meta-study also demonstrate the need for a standardized protocol / guideline that further supports the quality of case studies (i.e., that leads to more-complete

pictures of implementation processes). The meta-study yielded and validated a number of drivers and barriers, but gaps in data availability were also evident and thereby limited further insights and information exchange.

(3) The analytical scheme used in this study is a tool that can help to further improve the quality of case studies. The analytical scheme provides an overview of and makes suggestions for mutually understanding 111 variables that describe the context, influences, and achieved level of sustainability curriculum implementation process. The scheme provides a guideline and also invites HEIs to share their experiences in dealing with barriers, mistakes, and coping strategies. This analytical scheme can thereby serve to inform future case-study designs. Furthermore, it offers a tool with operationalized variables for further comparing and analyzing case studies on a larger scale.

8.3 Practical Contributions

The insights of this dissertation should serve to support the growing efforts of HEIs in taking responsibility for engaging in sustainability education across all disciplines. Two target groups can particularly benefit from and use the findings of this study to further initiate, adopt, and adapt sustainability curricula:

(1) First, stakeholders within an HEI – such as curriculum developers, administrators, and decision-makers as well as lecturers and students – can derive successful implementation strategies that can inform evidence-based considerations among higher education institutions worldwide. HEIs can utilize these insights on at least two levels:
   - Knowledge of the pertinent drivers can be used to begin and/or recalibrate a specific implementation process.
   - Higher education institutions and their stakeholders can reflect on the pattern within which they are currently operating. To achieve more comprehensive implementation of sustainability curricula, HEIs can compare the key driving factors behind the various patterns and derive further steps or coping strategies for dealing with certain barriers. For instance, missing internal support can be compensated for by external support, such as through an international research- or network project.

(2) As a second target group, external stakeholders – such as funding agencies, political decision-makers, and associations concerned with the development of curriculum theory and HESD (e.g., UNESCO, IAU, federal ministries) – can utilize the findings to identify leverage points for further supporting the implementation of ESD in higher education (e.g., by (a) granting more funding for research in thus-far underrepresented countries, (b) providing political support, or (c) facilitating knowledge exchange with a focus on experiences related to sustainability curriculum implementation processes and patterns). For instance, more international research projects on shared curricula or more intervention studies on implementing sustainability curricula in an HEI could be launched as this dissertation

demonstrated that one possibility for creating change is to bring in external support through (international) research projects or networks.

8.4 Future Research

While this meta-study yielded several insights into generalizable findings on sustainability curriculum implementation processes that are shared across different global contexts, it also stimulates further questions.

As already addressed in the section on limitations in the Discussion, the *data quality* of the case studies should be increased in order to derive better insights into implementation patterns. As qualitative data availability is the driving factor behind further investigating patterns, future researchers are advised to focus on (a) the quality of single case studies and (b) the scope of single and comparative case studies. In order to enhance the data quality of small-N case studies, the complexity of change should be carefully monitored, and it is necessary to be more explicit in determining the various factors that have and have not influenced ESD implementation, the different phases of the process, the achieved change, the implemented sustainability curricula with details on competence-oriented learning and teaching (as understood by Brundiers et al., 2021), the relationships between factors, and coping strategies when facing challenges (e.g., only investigating success stories should be avoided). It is also important to reflect on each specific context (what worked well in terms of traditions, organizational culture, country, etc.). Furthermore, the perspectives of various stakeholders – with their specific underlying assumptions – should find their way into the analysis of a given sustainability curriculum implementation process as stakeholders' motives play a key role in facilitating change. In general, case studies should be more analytical. For example, case studies could use intervention research to investigate the specific connections between driving and inhibiting influences and the achieved level of sustainability curriculum implementation.

To further assist in increasing data quality and in assessing the process and outcome of HESD implementation, an analytical scheme was developed as part of this work (Weiss & Barth, 2020c, see Appendix No. 5, Section 10.5). This framework can be applied in future case studies and should not only facilitate data analysis for case studies but also hopefully be continually developed throughout its further application.

Similarly, the inclusion of other types of publications – such as student theses or informal documents – could increase data quality. Additionally, the possibility of validating existing insights via primary data from surveys, interviews, or in-depth studies should be explored (as also discussed in Section 7). For example, in-depth studies of the identified sustainability curriculum implementation patterns could use additional data types to fill data gaps and thereby advance the understanding of the interlinked influences within a pattern.

Moreover, there is a call for reporting on organizational sustainability to focus more on education and to support planning for organizational change (Ceulemans et al., 2015; Madeira et al., 2011). Therefore, it would be possible to explore how sustainability reporting- and assessment efforts could enhance the implementation of sustainability curricula and enable new information and data points to be shared.

In order to broaden the scope of the HEIs analyzed in the case studies and to better understand the differences between different countries, future case studies should focus on countries that have thus far been underrepresented in the research landscape on sustainability curriculum implementation processes. During the course of the present study, several new case studies were published that provide insights from additional countries (e.g., Jun & Moon, 2021; Syed Azhar et al., 2020; Habib et al., 2021). Furthermore, the inclusion of other concepts that are similar to ESD could lead to a better understanding of the processes involved in implementing sustainability curricula and could thereby enable nuances of different implementation processes to be derived.

In order to address the question of how case studies can learn from one another, (inter)national *monitoring* could assist in identifying best practices if the monitoring databases are made available. Additionally, monitoring would provide data points on the current development trends of sustainability curricula in HEIs. Monitoring tools should ideally be developed in close cooperation with the implementing HEIs in order to ensure that the actual processes are accurately reflected. In addition, *networks*, corresponding publications, and knowledge exchange should all be further promoted in order to support their ability to learn from one another. A recently completed project from Germany (Hoch-N), for example, developed several guidelines for integrating sustainability into different areas of the HEI (http://hochnwiki.de).

Although it is important to improve the empirical database, it is equally as important to examine conceptual theories in order to advance the understanding of sustainability curriculum implementation processes. A brief investigation into the *theories that are applied to sustainability curriculum change in HEIs* reveals that the discourse on the subject is extensive and difficult to navigate. In contrast to the manifold theories and frameworks that can be applied to HESD (curriculum) change, only a few empirical case studies refer to "change theories". Similarly, even less discussion and questioning has taken place regarding how suitable some theories are for being applied to sustainability curriculum changes in higher education. Therefore, there is a need to structure and thus develop the discourse on theories that are concerned with or applicable to HESD (curriculum) change. Some open questions that have emerged from reflection on applied theories include: What theories are applied to sustainability curriculum implementation processes, and how do they differ in their assumptions? How do organizational change theories – which are often top-down and motivated by the need to be successful, innovation-driven, and profit-oriented – relate to universities as institutions? How do the different educational contexts and policies in different countries relate to different curriculum change theories? Is it necessary to develop an interplay between existing theories and empirical insights that take into account ideas from different existing theories from the fields of organizational change / learning, higher education curriculum change, or

sustainability transformation in order to theoretically embed sustainability curriculum change processes in HEIs?

Many aspects of the implementation processes of sustainability curricula thus remain under-researched, and the attempt to better understand such complex change- and transition processes will be an ongoing (collaborative) learning process that will ideally result in broadly embedding ESD in the core of higher education institutions around the globe. This dissertation represents one step in this journey by providing novel insights into generalizable drivers and barriers and uncovering specific sustainability curriculum implementation patterns. While it is important to try to understand and plan this change, it is even more important to embody the desired change in order to make it a new reality. The findings of this dissertation should help higher education institutions recognize their responsibility to move toward response-ability and responsible action.

Part V

References & Appendix

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10 APPENDIX

10.1 Appendix No. 1: Hypothesis Testing: Key Variables (Paper 2)

Detailed statistics for describing the distribution of the key variables used for hypothesis testing

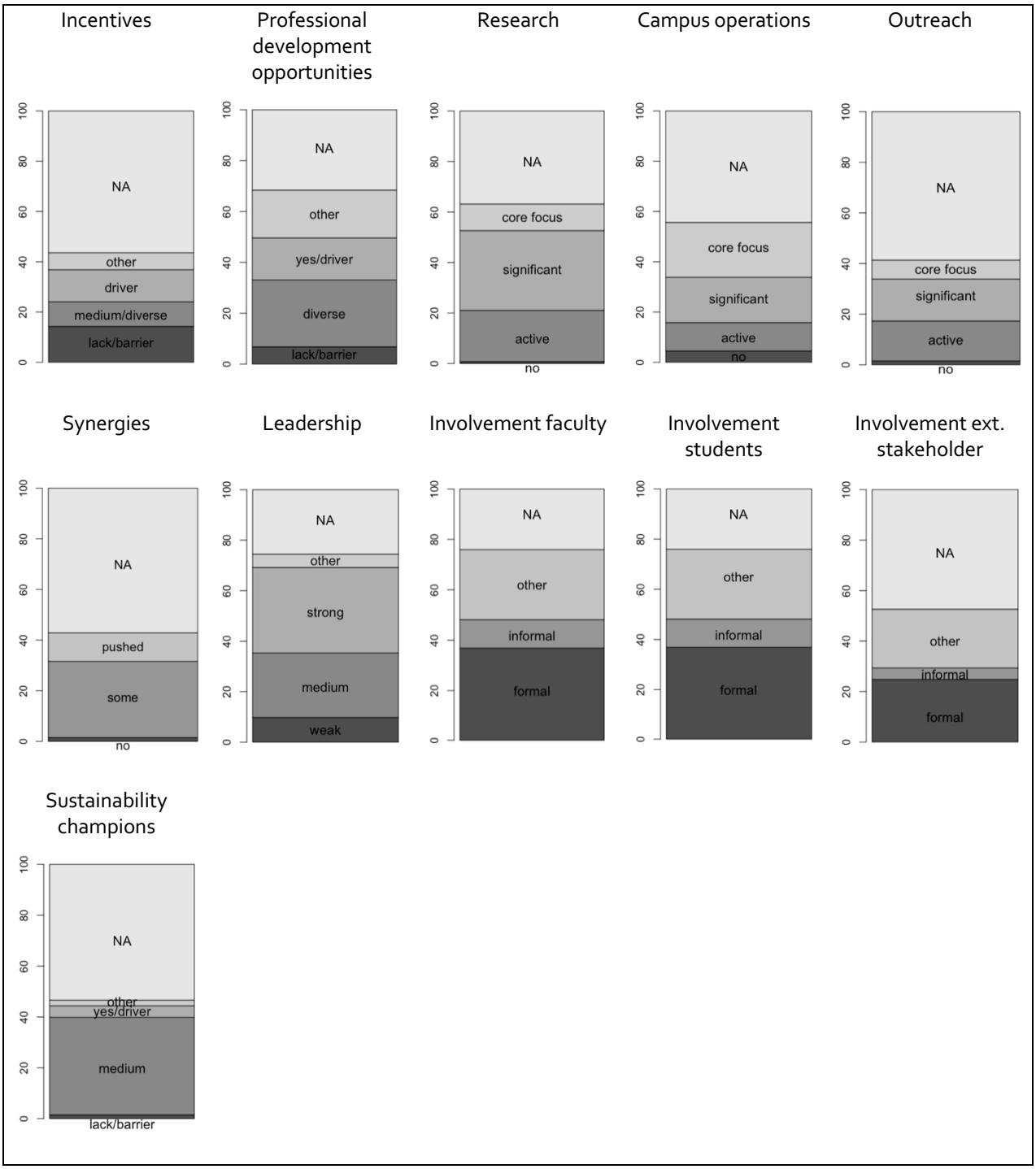

Figure 10.1 Frequency plots of central variables for sustainability curriculum implementation in higher education institutions. The y-axis displays the count in percent (N = 132 case studies)

10.2 Appendix No. 2: List of Case Studies (Paper 1, 2, 3)

The list of the case studies used in the analysis (N = 133) is presented below.

A full list with all publications is openly available here: Weiss & Barth, 2020b, https://bit.ly/EFCA-CaseUniverse.

Table 10.1 List of case studies that went into the analysis (N = 133); * Universities that were excluded from the cluster analysis

Continent	Country	Name of the Higher Education Institution
Africa	Botswana	University of Botswana (UB)
Africa	South Africa	Rhodes University
Africa	Tanzania	University of Dar es Salaam
Asia	China	Beijing Normal University (BNU)
Asia	China	Tsinghua University
Asia	India	Anna University
Asia	India	Indira Gandhi Open National University (IGOU)
Asia	India	Jadavpur University
Asia	India	Jammu University
Asia	India	Symbiosis International University
Asia	India	TERI University
Asia	India	University of Hyderabad
Asia	India	University of Madras
Asia	India	University of Pune
Asia	Indonesia	Universitas Gadjah Mada (UGM)
Asia	Iran	Amirkabir University of Technology (AUT)
Asia	Japan	Hokkaido University
Asia	Japan	Ibaraki University
Asia	Japan	Kobe University
Asia	Japan	Kyoto University
Asia	Japan	Osaka University
Asia	Japan	Shinshu University (SU)
Asia	Japan	University of Tokyo
Asia	Malaysia	National University of Malaysia
Asia	Malaysia	University Sains Malaysia (USM)
Asia	Oman	Sultan Qaboos University
Asia	Philippines	Miriam College
Asia	South Korea	Yonsei University (YU)
Asia	Thailand	Asian Institute of Technology (AIT)
Asia	Vietnam	Hanoi National University of Education (HNUE)

Continent	Country	Name of the Higher Education Institution
Asia	Vietnam	Ho Chi Minh University of Pedagogy (HCMUP)
Asia	Vietnam	Hue University of Education (HUEd)
Asia	Vietnam	Quang Nam University (QNU)
Asia	Vietnam	University of Da Nang, Danang University of Education (DUEd)
Europe	Bulgaria	University of Architecture, Civil Engineering and Geodesy (UACEG)*
Europe	Denmark	Aalborg University
Europe	Germany	Leuphana University
Europe	Germany	University of Tübingen
Europe	Greece	University of Aegean
Europe	Greece	University of Thessaloniki
Europe	Latvia	Daugavpils University
Europe	Latvia	Liepaja University (LiepU)
Europe	Latvia	Rezekne Higher Education Establishment (RHEE)
Europe	Latvia	University of Latvia
Europe	Netherlands	Delft University of Technology (DUT)
Europe	Netherlands	Eindhoven University
Europe	Netherlands	Erasmus University of Rotterdam
Europe	Netherlands	Van Hall Larenstein University of Applied Science
Europe	Spain	Technical University of Catalonia (UPC)
Europe	Spain	Technical University of Valencia (TUV)
Europe	Spain	University of Zaragoza
Europe	Sweden	Chalmers University of Technology
Europe	Sweden	KTH Royal Institute of Technology
Europe	Sweden	Linköping University
Europe	Sweden	Lund University
Europe	Switzerland	ETH Zurich
Europe	Switzerland	Zurich University of Applied Sciences
Europe	UK	Anglia Ruskin University
Europe	UK	Bournemouth University
Europe	UK	Cambridge University
Europe	UK	De Montfort University
Europe	UK	Newcastle University
Europe	UK	University of Bristol
Europe	UK	University of Gloucestershire
Europe	UK	University of Huddersfield
Europe	UK	University of Leeds

Continent	Country	Name of the Higher Education Institution
Europe	UK	University of Plymouth
Europe	UK	University of Southampton
Europe	UK	University of Strathclyde
Europe	UK	University of the West of England
Europe	UK	University of Wales Trinity Saint David
Latin America and the Caribbean	Brazil	Methodist University of São Paulo (Universidade Metodista de São Paulo (UMESP))
Latin America and the Caribbean	Ecuador	Universidad Técnica del Norte
Latin America and the Caribbean	Jamaica	University of the West Indies
Latin America and the Caribbean	Mexico	Metropolitan Autonomous University
Latin America and the Caribbean	Mexico	Monterrey Institute of Technology and Higher Education
Latin America and the Caribbean	Mexico	National Autonomous University of Mexico
Latin America and the Caribbean	Mexico	Universidad Veracruzana
Latin America and the Caribbean	Mexico	University of Sonora
North America	Canada	Bishop's University
North America	Canada	British Columbia Institute of Technology
North America	Canada	Dalhousie University
North America	Canada	Université de Sherbrooke
North America	Canada	University of Alberta
North America	Canada	University of British Columbia (UBC)
North America	Canada	University of Guelph
North America	Canada	York University
North America	USA	Arizona State University (ASU)
North America	USA	Berea College
North America	USA	California State University, Northridge (CSUN)
North America	USA	Carnegie Mellon University
North America	USA	Emory University
North America	USA	Ferrum College
North America	USA	Florida Gulf Coast University
North America	USA	George Washington University
North America	USA	Indiana University Bloomington
North America	USA	Ithaca College
North America	USA	James Madison University (JMU)

Continent	Country	Name of the Higher Education Institution
North America	USA	Johns Hopkins
North America	USA	Middlebury College
North America	USA	Northern Arizona University
North America	USA	Ohio State University (OSU)
North America	USA	Philadelphia University
North America	USA	Princeton
North America	USA	San José State University
North America	USA	Tulane University
North America	USA	Unity College
North America	USA	University of California, Santa Cruz (UCSC)
North America	USA	University of Colorado Boulder
North America	USA	University of Hawaii
North America	USA	University of Minnesota
North America	USA	University of New Hampshire
North America	USA	University of New Haven
North America	USA	University of Northern Iowa
North America	USA	University of Pennsylvania (Penn)
North America	USA	University of South Carolina
North America	USA	University of Utah
North America	USA	University of Vermont (UVM)
North America	USA	Yale
Oceania and Australia	12 Pacific Islands Nation	University of the South Pacific
Oceania and Australia	Australia	Deakin University*
Oceania and Australia	Australia	Edith Cowan University
Oceania and Australia	Australia	James Cook University (JCU)
Oceania and Australia	Australia	La Trobe University
Oceania and Australia	Australia	Monash University
Oceania and Australia	Australia	Murdoch University
Oceania and Australia	Australia	Oceania and Australian Catholic University
Oceania and Australia	Australia	Oceania and Australian National University (ANU)
Oceania and Australia	Australia	Royal Melbourne Institute of Technology (RMIT) University
Oceania and Australia	Australia	University of New South Wales
Oceania and Australia	Australia	University of South Oceania and Australia
Oceania and Australia	Australia	University of Tasmania
Oceania and Australia	Australia	University of Technology (UTS)
Oceania and Australia	Australia	University of Wollongong

10.3 Appendix No. 3: Cluster Analysis: List of Variables (Paper 3)

The list of variables that were used to compute the cluster analysis is presented below. Additional variables were used to add detail after cluster identification. Definitions and a full list of all variables can be found in the coding / analytical scheme (see Appendix No. 5).

2.3 CONTINENT, 2.7 SIZE HEI, 3.3 DIV SUS PROGRAMS, 3.4 DIV DISC, 3.4.1 DISC HUM SOC, 3.4.2 DISC NAT, 3.4.3 DISC LIFE SC, 3.4.4 DISC ENG, 3.4.5 DISC SUS, 3.5 INTERDISC SPACE, 3.6 STRCTR STUDY P, 3.7 TLA OVERALL (transformed into binary data), 3.9 SUPP CLT TL, 3.10 CROW CURR, 4.1 PERIOD SCIP START, 4.2 PERIOD SCIP END, 4.3 INSTITUTIONAL LEVEL SCIP, 4.4 INTEGRATION APRCH SCIP, 4.6 INI BU/TD, 4.7 WOO, 4.8 COORDINATION, 4.9 COMM, 5.1 STRAT PLAN, 5.2 VISION, 5.3 RES BUDGET, 5.4 RES TIME, 5.5 RES O, 5.6 INT PRIORITY FRML/INFRML, 5.7 LEADERSHIP, 5.8 COLL ENVRNMT, 5.9 ORG STRCT, 6.1 PROF DEVELOP, 6.2 INCTIV, 6.3 QA, 7.1 INVOLV FACULTY, 7.2 INVOLV STUDENTS, 7.4 INVOLV EXT STAKEH, 7.5 SUPP MGMT, 7.6 SUPP ADMIN, 7.7 SUPP FACULTY, 7.9 INTERDIS COMP FACULTY, 7.10 PERC SD FACULTY, 7.13 ATT ITL FACULTY, 7.14 PERC CURR LINKS FACULTY, 7.15 ACC STUDENTS, 7.16 ENGAGE STUDENTS, 7.17 SUS CHAMP, 8.3 MARKET F, 8.5 PUB DISC, 8.6 GOVERNM, 8.7 CONTEXT O, 9.1 GOA, 9.2 RATING SUS IMPLEMENTATION, 9.3 GOA RESEARCH, 9.4 GOA CAMPUS, 9.5 GOA OUTREACH, 9.6 GOA SYN, 9.7 GOA ORIGIN

10.4 Appendix No. 4: Cluster Analysis: Supplementary material for characterizing the identified clusters (Paper 3)

An Excel file with additional and detailed information on each cluster that includes their different expressions of analyzed variables is presented below.

Category	Variable	Value label	Cluster 1: Collaborative paradigm change	Cluster 2: Bottom-up, evolving institutional change	Cluster 3: Top-down, mandated institutional change	Cluster 4: Externally driven initiatives	Cluster 5: Isolated initiatives	Cluster 6: Limited institutional change
Context pattern description	**N cases**	Number of cases	19	26	30	22	26	8
	Diversity of disciplines	• weak diversity (1-2 disciplines are taught) • medium diversity (3 are taught) • high diversity (4 are taught) • NA	*mostly high* 13x high, 6x medium Notes: 11 cases have a sustainability faculty/center)	*mostly high* 21x high, 4x medium, 1x weak Notes: 11 cases have a sustainability faculty/center)	*mostly high* 21x high, 7x medium, 2x weak Notes: 11 cases have a sustainability faculty/center	*mostly high* 19x high, 2x medium, 1x weak Notes: 3 cases have a sustainability faculty/center	*mostly high* 19x high, 4x weak, 3x medium Notes: 6 cases have a sustainability faculty/centermostly no sus faculty	*mostly high* 6x high, 1x weak, 1x NA, 0x medium Notes: 1 case has a sustainability faculty/center
	Country	• list of countries, in which the HEIs are located	*differing, but mostly European cases* 5x the UK, 3x Australia, 2x the Netherlands, 2x the USA, 2x Canada, 1x Denmark, 1x Malaysia, 1x South Africa, 1x Spain, 1x Sweden	*differing* 9x the USA, 5x Australia, 4x Mexico ,2x Canada, 2x Germany, 1x 12 Pacific Island Nations, 1x Brazil, 1x the Netherlands, 1x the UK	*differing, but mostly North-American cases* 15x the USA, 3x the UK, 2x Australia, 2x Canada, 2x India, 1x China, 1x Japan, 1x Mexico, 1x Philiippines, 1x Sweden, 1x Switzerland	*differing, but only Asian & European cases* 7x India, 6x Japan, 1x Indonesia, 2x the UK , 1x South Korea, 1x Thailand, 1x Spain, 1x Sweden, 1x Switzerland, 1x the Netherlands	*differing* 4x Latvia, 4x the USA, 2x Australia, 2x Canada, 2x the UK , 2x Greece, 1x Botswana, 1x Iran, 1x Jamaica, 1x Malaysia, 1x Oman, 1x Spain, 1x Tanzania, 1x China, 1x Ecuador, 1x Sweden	*differing* 5x Vietnam, 1x Australia, 1x the UK, 1x the USA
	Size	• ≥ 30,000 students • ≥ 12,000 students • ≥ 5,000 students • ≤ 5,000 students • NA	*mostly big- or middle-sized HEIs* 9x ≥ 12,000 students, 7x ≥ 30,000 students, 3x ≥ 5,000 students	*mostly big- or middle-sized HEIs* 12x ≥ 30,000 students, 10x ≥ 12,000 students, 2x ≥ 5,000 students, 2x ≤ 5,000 students	*mostly middle- or big-sized HEIs* 14x ≥ 12,000 students, 8x ≥ 30,000 students, 5x ≤ 5,000 students, 2x NA, 1x ≥ 5,000 students	*mostly middle- or small-sized HEIs* 9x ≥ 12,000 students, 6x ≥ 5,000 students , 4x ≥30,000 students, 3x ≤ 5,000 students	*mostly middle- or big-sized* 11x ≥ 12,000 students, 9x ≥ 30,000 students, 3x ≤ 5,000 students, 2x ≥ 5,000 students, 1x NA	*mostly small- or middle-sized* 3x ≥ 5,000 students, 1x≥ 30,000 students, 2x ≥ 12,000 students, 2x NA
Level of implementation	**Implementation level**	• denial • bolt-on ((Sustainability issues inform disciplinary topics with the integration of sustainability into existing courses or program(s).) • build-in (Sustainability is tackled via interdisciplinary collaboration with the creation of a new discipline or cross-disciplinary sustainability courses or programs. Or, ESD is at least in HEI's current vision (HEI's annual report or website) plus in ESD courses/programs.) • redesign (Sustainability issues are integrated into common core requirements and/or the vision vision—case material (earlier stage – depends on publication date) and online (current state)—of the HEI.	*mostly redesign & build-in with redesign tendencies* 11x build-in, 7x redesign, 1x bolt-on	*mostly build-in or redesign* 16x build-in, 9x redesign, 1x bolt-on	*mostly build-in* 21x build-in, 5x redesign, 4x bolt-on	*mostly build-in & bolt-on* 12x build-in, 9x bolt-on, 1x no change	*mostly bolt-on & build-in* 15x bolt-on, 11x build-in	*mostly bolt-on & build-in* 5x bolt-on, 3x build-in
	Institutional level	Level, that is described in the publications: • institution • division (e.g., faculty/school/center level) • program • course • other • NA	*mostly institution-wide* 16x institution, 1x department,1x program, 1x minor	*mostly institution-wide* 20x institution, 4x other, 2x course	*mostly institution-wide* 18x institution, 6x other, 4x division, 2x course	*differing* 7x institution, 5x other, 4x program, 3x division, 3x course	*differing* 8x institution, 8x other, 5x course, 4x division, 1x NA	*institution-wide (attempt)* 8x institution
	Integration approach	• integration of sustainability as a minor subject in existing course(s) • integration of sustainability as a minor subject in existing program(s) • integration of sustainability in a minor • new (re)design of program(s) (major) focused on sustainability • general studies approach integration of sustainability as a subject in diff. parts in university curriculum • creation of new sustainability department (chairs, institutes etc. are included) • other • NA	*mostly general studies approach* 15x general studies approach, 2x sustainability faculty, 1x new program(s) (major), 1x other	*mostly general studies approach* 19x general studies approach, 3x other, 2x minor subject in existing course(s), 2x sustainability faculty	*mostly general studies approach* 16x general studies approach, 8x other, 3x NA, 2x new program(s) (major), 1x sustainability faculty	*differing* 10x other, 5x general studies approach, 3x minor subject in existing program(s), 2x new program(s) (major), 1x minor subject in existing course(s), 1x sustainability faculty	*differing* 9x other, 7x general studies approach, 6x subject in existing course(s), 2x minor in existing program(s), 1x sustainability faculty, 1x NA	*differing* 2x minor subject in existing course(s), 2x minor subject in existing program(s), 1x sintegration of sustainability in a minor, 1x new program(s) (major) focused on sustainability, 1x general studies approach, 1x sustainability faculty

Process	**Grade of activity**	• recently started activities, meaning for <5y • established activities, meaning for 5-10y • long tradition of activities, meaning >10y	*long tradition* 19x long tradition	*mostly long tradition* 21x long tradition, 4x established, 1x NA	*mostly long tradition* 23x long tradition, 6x established, 1x NA	*mostly long tradition* 21x long tradition, 1x established	*differing, mostly long tradition or established* 14x long tradition, 5x established, 2x recently started, 5x NA Notes: Tendency that bolt-on cases don't have long tradition of activities	*mostly long tradition* 7x long tradition, 1x established
	Origin	• research • teaching & learning (T&L) • campus operation • outreach • other • NA	*differing, mostly other & campus operations* 9x NA, 5x other, 4x campus operation, 1x T&L	*differing, mostly T&L* 14x NA, 7x T&L, 2x research, 2x campus operation, 1x other	*differing* 20x NA, 4x T&L, 3x other, 2x campus operation, 1x research	*differing* 19x NA, 2x research, 1x campus operation	*differing* 22x NA, 2x T&L, 2x other	*differing, mostly T&L* 5x T&L, 1x campus operation, 2x NA
	Initiation	• bottom-up • top-down • other (=both) • NA	*mostly both (top-down and bottom-up)* 6x other, 6x NA, 4x top-down, 3x bottom-up	*mostly bottom-up* 16x bottom-up, 8x other, 1x top-down, 1x NA	*mostly top-down* 11x top-down, 10x other, 1x bottom-up, 8x NA	*mostly other* 9x other, 4x top-down, 2x bottom-up, 7x NA	*differing* 4x bottom-up, 4x other, 3x top-down, 15x NA	*mostly NA* 1x other, 7x NA
Institutional Environment	**Strategic plan**	• lack of, described as a barrier • medium/differing • yes, described as a driver • other • NA	*mostly driver* 15x driver, 2x differing/medium, 1x lack of, 1x NA	*mostly driver* 19x driver, 3x differing/medium, 2x other, 2x NA	*mostly driver* 17x driver, 7x NA, 4x differing/medium, 2x other	*NA* 22x NA	*mostly medium or other* 10x differing/medium, 7x other, 6x NA, 3x driver	*mostly lack of* 7x lack of, 1x differing
	Vision	• not mentioned in vision • mentioned in current vision, which is available online • mentioned in current vision, which is available online and described as a driver in case material • other (e.g., mentioned in case material, but not available online) • NA	*mostly driver* 11x case material and current online vision, 4x current online vision, 3x other, 1x lack of	*mostly driver* 16x case material and current online vision, 3x current online vision, 3x lack of, 3x other, 1x NA	*partly driver* 13x case material and current online vision, 7x lack of, 4x current online vision, 5x other, 1x NA Notes: Focus is more on the environmental dimension opposed to a holistic sustainability definition	*differing* 7x lack of, 7x current online vision, 3x case material and current online vision, 3x other, 2x NA	*mostly lack of* 12x lack of, 5x current online vision, 4x other, 4x NA, 1x case material and current online vision	*mostly lack of* 7x lack of, 1x current online vision
	Resources	• lack of, described as a barrier • medium/differing • enough resources, described as a driver • other • NA	*differing* budget: 6x medium, 5x lack of, 5x NA , 2x other, 1x some budget as a driver time: 9x lack of, 5x NA, 2x medium, 2x other, 1x enough time	*differing* budget: 12x some budget as a driver, 6x lack of, 5x NA, 2x differing, 1x other time: 11x NA, 10x lack of, 2x driver, 2x other, 1x differing	*mostly NA, differing* budget: 15x NA, 7x driver, 6x differing, 2x lack of time: 26x NA, 2x driver (extra time), 1x lack of, 1x differing	*mostly NA* budget: 12x NA, 8x other, 2x driver time: 22x NA	*mostly NA, partly lack of* budget: 15x NA, 7x lack of, 3x other, 1x differing time: 19x NA, 5x lack of, 1x differing, 1x other	*lack of* 8x lack of (budget and time)
	Professional development opportunities	• lack of, described as a barrier • medium/differing • yes, described as a driver • other • NA	*mostly driver or medium* 8x driver, 5x differing/medium, 3x other, 2x NA, 1x lack of	*mostly driver* 16x driver, 4x other, 3x NA, 2x differing/medium, 1x lack of Notes: First informal communities of practice, later more formalized support	*partly in place, mostly driver or medium* 10x NA, 8x driver, 7x differing/medium, 4x other, 1x lack of	*differing, mostly weak* 11x other, 8x NA, 2x differing/medium, 1x driver	*differing, mostly NA* 14x NA, 4x medium/differing, 3x other, 3x lack of, 2x driver	*differing, mostly weak* 4x NA, 2x lack of, 2x differing/medium
	Incentives	• lack of, described as a barrier • medium/differing • yes, described as a driver • other • NA	*differing* 7x NA, 4x driver, 3x lack of, 3x medium/differing, 2x other	*differing, mostly lack of or medium impact* 9x NA, 7x lack of, 6x medium, 3x driver, 1x other	*partly in place, mostly medium or driving impact* 16x NA, 6x driver, 4x medium, 3x other, 1x lack of	*mostly NA, partly lack of* 16x NA, 3x lack of, 2x other, 1x differing	*mostly NA, partly ack of* 21x NA, 2x lack of, 2x differing, 1x other	*mostly NA or lack of* 5x NA, 3x lack of
	Communication	• lack of, described as a barrier • differing/in place but unclear impact • yes, described as a driver • other • NA	*mostly driver* 14x driver, 5x medium Notes: Visioning process, sustainability map to show sustainability across university	*mostly driver* 20x driver, 3x NA, 2x other, 1x differing Notes: Web portal to provide vehicle for horizontal implementation, communities of practice	*partly driver* 12x driver, 10x differing, 6x NA, 2x lack of	*differing, mostly NA* 16x NA, 4x differing, 1x driver, 1x other	*differing, mostly weak* 11x differing, 8x NA, 4x lack of, 2x driver, 1x other	*differing, mostly weak* 5x NA, 1x driver, 1x differing, 1x lack of
	Coordination	• lack of, described as a barrier • medium/differing • yes, described as a driver • other • NA	*mostly driver* 17x driver, 1x other, 1x NA	*mostly driver* 21x driver, 3x differing, 1x lack of, 1x NA	*mostly driver* 20x driver, 6x differing, 2x other, 2x NA	*differing* 15x NA, 4x other, 2x driver, 1x differing Notes: If described, mostly external coordination with other HEIs	*differing, mostly weak* 16x NA, 4x differing, 3x driver, 2x lack of, 1x other	*mostly weak* 4x NA, 3x differing, 1x lack of
	Quality assurance mechanisms	• lack of • occasional/differing • established • research method (quality assurance mechanisms are used as a research method in the case studies, but it is unclear if they are institutionalized) • other • NA	*mostly at least occasionally used* 11x occasional, 4x research method, 2x established, 1x other, 1x NA	*differing* 7x NA, 6x occasional, 4x lack of, 4x other, 3x research method, 2x established	*partly established or occasionally used* 10x NA, 7x established, 7x occasional, 2x lack of, 2x research method, 2x other	*differing* 12x NA, 4x other, 3x established, 2x occasional, 1x research method	*differing* 11x NA, 7x occasional, 5x research method, 2x lack of, 1x other	*mostly used as part of a research project* 5x research method, 2x occasional, 1x other

	Organizational structure	• lack of structure, described as a barrier • differing • sufficient (changed) structure, described as a driver • other • NA	*often adaptation of existing structure* 8x differing, 6x NA, 4x lack of structure, 1x driver	*differing* 10x lack of, 9x NA, 4x driver, 2x differing, 1x other	*partly driver or adaptation of existing structure* 14x NA, 9x driver, 5x differing, 2x lack of	*mostly NA* 20x NA, 1x driver, 1x differing	*mostly weak* 17x NA, 6x lack of, 1x driver, 1x differing, 1x other	*lack of* 7x lack of, 1x NA Notes: Crowded curriculum described as a barrier
Educational environment	**Internal collaborative culture**	• barrier (the competitive environment of the organization is described as a barrier or the collaboration needs to be strengthened) • medium/differing (some or differing efforts to work collaboratively, but not described as a barrier) • driver (the collaborative environment of the organization is described as a driver) • other • NA	*mostly driver* 8x NA, 6x medium, 5x driver	*mostly driver* 15x driver, 7x NA, 3x medium, 1x lack of Notes: Emphasis on the attempt to build solidarity, collaborative events	*partly in place, but insufficient* 13x NA, 9x medium, 8x driver	*mostly NA, or external collaboration with other HEI* 15x NA, 6x other, 1x competitive	*differing, mostly weak* 16x NA, 5x medium, 3x competitive, 2x driver	*weak* 6x competitive, 2x NA
	Interdisciplinary space	• lack of, described as a barrier • differing • yes, described as a driver • other • NA	*mostly driver* 15x driver, 2x other, 2x NA	*differing, partly driver* 11x driver, 10x NA, 3x lack of, 1x differing, 1x other	*differing, mostly driver* 17x driver, 10x NA, 2x other, 1x differing	*differing, mostly NA* 19x NA, 3x driver	*differing, mostly NA* 14x NA, 5x driver, 4x lack of, 2x other, 1x differing	*differing, mostly lack of* 5x lack of, 2x driver, 1x other
Internal stakeholders	**Leadership**	• weak leadership (no support, no interest, no awareness) • inconsistent leadership (changes in the top management, different phases, changing priorities, vision but no strategy) • strong leadership (strong support, e.g., vision, strategic planning, incentives) • NA	*mostly strong* 13x strong, 3x NA, 2x medium, 1x weak	*mostly inconsistent* 18x inconsistent, 4x strong, 3x other, 1x NA	*mostly strong* 22x strong, 6x inconsistent, 2x other	*mostly NA* 19x NA, 2x other, 1x strong	*differing* 11x NA, 7x differing, 5x strong, 3x weak	*weak* 8x weak
	Faculty support	• no support, described as a barrier • medium/differing support • high support, described as a driver • other • NA	*mostly medium or high* 12x medium, 5 high, 2x NA	*mostly high or medium* 10x high, 9x medium, 5x NA, 2x other	*mostly medium or high* 15x medium, 7x high, 4x other, 4x NA Notes: Some resistance as ownership is missing	*weak* 15x NA, 7x medium	*differing* 8x NA, 6x differing, 5x strong, 5x other, 2x lack of	*medium support* 7x medium, 1x NA
	Students support	• no acceptance, described as a barrier • medium/differing acceptance • high acceptance, described as driver	*mostly high* 10x high, 4x other, 3x NA, 2x differing	*mostly high* 13x high, 11x NA, 1x differing, 1x other	*partly high or medium* 15x NA, 6x high, 6x medium, 3x other	*differing, mostly NA* 14x NA, 4x high, 4x differing	*partly high or medium* 11x NA, 8x high, 6x differing, 1x other	*medium* 7x differing, 1x NA
	Sustainability champions	• lack of, described as a barrier • medium • yes, described as a driver • other • NA	*mostly driver* 13x driver, 5x NA, 1x other	*mostly driver* 18x driver, 7x NA, 1x other	*partly driver* 18x NA, 11x driver, 1x medium	*differing, mostly NA* 16x NA, 4x differing, 1x driver, 1x other	*differing, mostly NA* 20x NA, 5x driver, 1x differing	*mostly NA or lack of* 5x NA, 2x lack of, 1x driver Notes: Some champions leave the institution due to missing support, which leads to lack of more champions.
	Involvement internal stakeholder	• lack of • formal (participation led by the university) • informal (personal initiative) • other (e.g., involvement through research method, or unclear involvement) • NA	*mostly formal* Faculty: 16x formal, 3x other Students: 15x formal, 3x NA, 1x other	*differing* Faculty: 12x other, 7x formal, 5x informal, 2x NA Students: 9x formal, 9x NA, 6x other, 2x informal Notes: The "other" value label describes an involvement that is not explicitly described as informal or formal, but is evident in the process description	*mostly formal* Faculty: 18x formal, 7x other, 4x NA, 1x informal Students: 13x formal, 10x NA, 4x other, 3x informal	*mostly NA, partly formal* Faculty: 12x NA, 4x formal, 4x other, 2x informal Students: 16x NA, 5x formal, 1x informal	*differing* Faculty: 8x other, 8x NA, 6x informal, 4x formal Students: 13x NA, 5x formal, 5x other, 3x informal	*mostly NA* Faculty: 6x NA, 2x other Students: 6x NA, 2x other
	Interdisciplinary competence - faculty	• lack of competence, described as a barrier • medium/differing competence • high competence, described as a driver • other • NA	*differing* 6x medium/differing, 5x lack of, 4x other, 3x driver, 1x NA	*differing, mostly NA* 14x NA, 6x lack of, 3x driver, 3x differing	*mostly NA, or high or medium competence* 14x NA, 6x driver, 5x medium, 4x other, 1x lack of	*weak* 13x NA, 9x lack of	*differing, mostly lack of* 10x lack of, 7x differing, 5x NA, 2x high, 2x other	*lack of* 7x lack of, 1x NA
	Perception of curriculum links - faculty	• negative perception, described as a barrier • medium/differing perception • positive perecption, described as a driver • other • NA	*mostly medium* 12x medium/differing, 4x other, 2x NA, 1x positive	*differing, mostly NA* 19x NA, 2x negative, 2x differing, 2x positive, 1x other	*mostly NA* 26x NA, 3x differing, 1x other	*mostly NA* 14x NA, 5x differing, 3x other	*mostly NA or weak* 18x NA, 4x differing, 3x other, 1x negative	*mostly NA* 6x NA, 2x differing

	Perception of sustainable development - faculty	• negative perception, barrier • medium/differing perception • positive perception, driver • other • NA	*mostly medium or positive* 10x medium/differing, 4x positive, 4x NA, 1x other	*mostly NA, sporadically positive* 18x NA, 5x positive, 2x other, 1x differing	*mostly NA, partly differing* 16x NA, 10x differing, 4x positive	*mostly NA, partly differing* 14x NA, 8x differing	*differing, mostly NA* 16x NA, 7x differing, 1x positive, 1x negative, 1x other	*mostly NA* 6x NA, 2x differing
	Attitude towards innovative teaching and learning methods - faculty	• negative attitude, barrier • medium/differing attitude • positive attitude, driver • other • NA	*differing, partly positive* 8x NA, 6x positive, 3x differing, 2x other	*mostly NA* 22x NA, 2x differing, 2x other	*mostly NA, partly positive* 21x NA, 7x positive, 1x differing, 1x other	*mostly NA, partly differing or positive* 14x NA, 5x differing, 3x positive	*differing, mostly NA* 18x NA, 4x positive, 3x differing, 1x negative	*mostly lack of* 4x negative, 2x differing, 1x other, 1x NA
External influences	**Window of opportunity**	• lack of, described as a barrier • differing • yes, described as a driver • other • NA	*mostly driver* 13x driver, 6x NA	*partly driver* 14x driver, 10x NA, 1x differing, 1x other Notes: Change in faculty or top management, environmental threats or environmental movement	*mostly NA, partly driver* 19x NA, 10x driver, 1x other Notes: Change in top management, need to restructure, need to save energy (oil crisis)	*partly driver* 11x driver, 10x NA, 1x other Notes: Political support, environmental threats	*mostly NA, sporadically driver* 21x NA, 4x driver, 1x lack of Notes: Financial crisis as a chance to implement an ESD business course (one case)	*mostly driver* 7x driver, 1x NA Notes: Change in top management, political support
	Government	• none, described as a barrier • medium • yes, described as a driver • other • NA	*mostly driver* 9x driver, 5x NA, 3x medium, 2x other	*mostly NA, partly driver* 15x NA, 7x driver, 2x differing, 2x other	*mostly NA, partly driver* 19x NA, 10x driver, 1x differing	*mostly driver* 12x driver, 9x NA, 1x medium	*mostly NA, partly driver* 13x NA, 8x driver, 5x medium Notes: Especially the build-in cases report a positive influence of the ESD decade and UNESCO chairs; the bolt-on cases describe a medium influence	*mostly driver* 6x driver, 2x NA Notes: Especially the Vietnam cases report a support coming from the UNESCO
	Market forces	• none, described as a barrier • medium • yes, described as a driver • other • NA	*mostly driver* 12x driver, 6x NA, 1x medium	*mostly NA, partly medium or driving influence* 15x NA, 6x medium/differing, 3x driver, 2x other	*mostly NA, sporadically driver* 22x NA, 4x driver, 3x other, 1x differing	*mostly NA, sporadically driver* 12x NA, 8x driver, 1x lack of, 1x other	*mostly NA* 20x NA, 2x driver, 2x medium, 2x other	*mostly NA* 7x NA, 1x medium
	Public discourse	• none, described as a barrier • medium • yes, described as a driver • other • NA	*mostly NA or driver* 9x NA, 8x driver, 1x medium, 1x lack of	*mostly NA, partly driver* 19x NA, 7x driver	*mostly NA, sporadically driver* 23x NA, 4x driver, 2x differing, 1x other	*mostly NA, sporadically driver* 15x NA, 7x driver	*mostly NA* 24x NA, 1x driver, 1x medium	*mostly NA* 6x NA, 1x lack of, 1x medium
	External influence_other	• yes • no (not described)	*mostly strong* 16x yes, 3x no Notes: Cooperations with other HEIs through networks or RCEs	mostly strong 22x yes, 4x no Notes: Networks, partner HEI, local community	*differing* 15x yes, 15x no	*mostly strong* 21x yes, 1x no Notes: Often through international networks, NGOs, RCE	*partly strong* 19x yes, 7x no Notes: The HEIs with weak local support often use instead international collaboration through research projects	*partly strong* 6x yes, 2x no Notes: NGO
	Involvement external stakeholder	• lack of • formal (participation led by the university) • informal (personal initiative) • other • NA	*mostly formal* 11x formal, 5x NA, 3x other	*mostly NA, partly formal* 14x NA, 8x formal, 4x other	*mostly NA, partly formal* 15x NA, 12x formal, 3x other	*NA* *22x NA* Notes: The value label "other" describes mostly research projects with international HEIS, NGOs, UNESCO, etc.	*mostly NA, or through research projects* 16x NA, 9x other, 1x formal	*mostly informal* 5x informal, 3x NA
Sustainability areas	**Sustainability research**	• no specific activities • active (the area is mentioned, but is not the focus of the HEI) • significant (the commitment becomes visible in projects, initiatives etc.) • core focus (the commitment becomes visible in projects, initiatives etc., and the commitment is determined in strategic papers, vision etc.) • NA	*mostly significant or core activity* 8x significant, 5x core, 3x active, 3x NA	*mostly significant activity* 10x significant, 9x NA, 4x core, 3x active	*mostly significant activity* 12x significant, 8x NA, 7x active, 3x core	*mostly NA, or significant activity* 13x NA, 6x significant, 2x active, 1x core	*mostly NA, or active or significant activity* 10x NA, 9x active, 6x significant, 1x core	*NA or active activity* 5x NA, 3x active
	Campus sustainability	• no specific activities • active (the area is mentioned, but is not the focus of the HEI) • significant (the commitment becomes visible in projects, initiatives etc.) • core focus (the commitment becomes visible in projects, initiatives etc., and the commitment is determined in strategic papers, vision etc.) • NA	*mostly active or core activity* 8x active, 6x core, 4x NA, 1x significant	*mostly core or significant activity* 10x core, 9x significant, 6x NA, 1x active	*mostly significant or core activity* 11x significant, 9x core, 9x NA, 1x active	*mostly NA* 21x NA, 1x active	*differing, mostly NA* 19x NA, 3x core, 3x active, 1x significant	*differing, mostly no activity* 5x no activity, 2x significant, 1x active

	Sustainability outreach activities	• no specific activities • active (the area is mentioned, but is not the focus of the HEI) • significant (the commitment becomes visible in projects, initiatives etc.) • core focus (the commitment becomes visible in projects, initiatives etc., and the commitment is determined in strategic papers, vision etc.) • NA	*differing, mostly significant activity* 7x significant, 6x NA, 4x active, 2x core	*mostly NA, partly differing activities* 14x NA, 6x active, 3x significant, 3x core	*mostly NA, partly differing activities* 12x NA, 6x significant, 6x active, 5x core, 1x no activity	*mostly NA* 20x NA, 2x significant	*mostly NA, sporadically active or significant activity* 17x NA, 5x active, 4x significant	*NA* 8x NA
	Synergies btw. diff. areas	• no specific synergies • some synergies are described • synergies are pushed • NA	*mostly described or pushed for* 11x some, 5x NA, 3x pushed	*mostly described or pushed for* 11x NA, 8x some, 7x pushed	*mostly some synergies are described, but less pushed for* 15x some, 12x NA, 3x pushed	*mostly NA* 20x NA, 2x some	*differing, mostly NA* 20x NA, 3x some, 2x pushed, 1x no activities	*NA* 8x NA

Legend: The color code indicates whether the factor worked as a driver or as a barrier/ was strong or weak/ high or low. For variables, in which other value labels were used, no color code is applied. The color code should ease the comparison between the various clusters and should highlight some differences and tendencies. The detailed descriptions of the variables can be found in Weiss M, Barth M (2020) 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. ISSN (online) 2700-6735

driver
medium
barrier

10.5 Appendix No. 5: EFCA Analytical Scheme (Paper 2, 3)

Weiss, M. & Barth, M. (2020). Comparative Analysis of Sustainability Curriculum Implementation Processes in Higher Education Institutions: A Variable-Based Analytical Scheme. Working Papers in Higher Education for Sustainable Development, No. 1/2020. Leuphana University Lüneburg, Center for Global Sustainability and Cultural Transformation.

Comparative Analysis of Sustainability Curricula Implementation Processes in Higher Education Institutions: A Variable-based Analytical Scheme

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Working Papers in Higher Education for Sustainable Development Series

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Comparative Analysis of Sustainability Curricula Implementation Processes in Higher Education Institutions: A Variable-based Analytical Scheme

Marie Weiss, Center for Global Sustainability and Cultural Transformation, Faculty of Sustainability, Leuphana University of Lüneburg, Lüneburg, Niedersachsen, Germany
marie.weiss@leuphana.de

Matthias Barth, Center for Global Sustainability and Cultural Transformation and Institute for Integrative Studies, Faculty of Sustainability, Leuphana University of Lüneburg, Lüneburg, Niedersachsen, Germany
matthias.barth@leuphana.de

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Arizona State University

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Editorial

Working Papers in Higher Education for Sustainable Development is a series dedicated to publishing recent insights and discussions from *ongoing* research projects in the field of Higher Education for Sustainable Development. One major goal is to make detailed case descriptions, notes on methods, research designs, and related information available in a transparent fashion which usually exceeds the scope of journal articles. Fellow researchers, scholars and practitioners are invited to comment, discuss and contribute their thoughts and experiences. This working papers series is published by the joint "Center for Global Sustainability and Cultural Transformation" (CGSC), a transatlantic academic collaboration between Leuphana University of Lüneburg and Arizona State University.

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Prof. Dr. Matthias Barth; Prof. Dr. Arnim Wiek

Center for Global Sustainability and Cultural Transformation
Leuphana University Lüneburg
Universitätsallee 1
21335 Lüneburg, Germany

Abstract

English

Sustainable development depends on the broad implementation of sustainability curricula across higher education institutions. While this belief is widely shared, little empirical evidence and generalizable results have been generated of such implementation processes and specific driving and hindering factors. This paper provides a scheme for analyzing these processes. The scheme can be used to analyze a single case or a few case studies, but its primary appeal lies in enabling comparisons and meta-analyses of a large number of case studies. Its application will deepen the understanding of sustainability curricula implementation processes in higher education institutions.

Key words: higher education, university, education for sustainable development, sustainability, curricula, implementation process, drivers, barriers, meta-analyses, case survey method

Deutsch

Die nachhaltige Entwicklung unserer Gesellschaft hängt wesentlich davon ab inwiefern Nachhaltigkeitsthemen Einzug in die Programme, Kurse und Curricula der Bildungseinrichtungen, v.a. der Hochschulen finden. Während diese Ansicht etabliert ist und geteilt wird, finden sich kaum empirische Arbeiten mit hohen Fallzahlen zu den eigentlichen Implementierungsprozessen und den entscheidenden Barrieren und Treibern. Erkenntnisse zu Implementierungsprozessen liegen bisher nur in einzelnen Fallstudien oder Vergleichen mit geringen Fallzahlen vor.

Das vorliegende analytische Gerüst ermöglicht einen Vergleich von einer hohen Anzahl von Fallstudien, die über Implementierungsprozesse von Nachhaltigkeitscurricula an Hochschulen berichten. Damit wird ermöglicht auch eine sehr große Anzahl von Fallstudien in einer Meta-Analyse zu vergleichen, um generalisierbare Erkenntnisse zu erhalten.

Key words: Hochschulbildung, Universität, Bildung für nachhaltige Entwicklung, Nachhaltigkeit, Implementierung, Meta-Analyse, case survey Methode

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Part I

Introduction

1.1 The Educating Future Change Agents Project

The *Educating Future Change Agents* (EFCA) project produced empirical insights on how higher education can support students' development of key competencies in sustainability. The project was conducted 2016-2020 as a joint research project between Leuphana University of Lüneburg, Germany and Arizona State University, Tempe, Arizona, USA. The project was structured into five studies, which conducted in-depth case studies and comparative studies on the course, curriculum, and institutional level. The specific cases were selected so as to have a high degree of both similarities and variances within and across cases and to represent the widely recognized fields of sustainability education, namely, education of sustainability professionals, teachers, and entrepreneurs.

All studies were grounded in a shared analytical framework that informed both data collection and analysis. Based on this framework, each study adopted its own suite of research methods appropriate for the respective research questions, while still coordinating and sharing insights on methods among the studies. Each study produced a set of results specific to the specific case(s) and contexts. In the final phase of the project, results from the individual studies were synthesized to offer general insights for researchers, educators, and administrators in the field of sustainability education.

Results of the EFCA project have been published and can be found on ResearchGate: https://www.researchgate.net/project/Educating-Future-Change-Agents. This working paper series provides previously unpublished background material and additional information to facilitate deeper understanding of the research carried out. The working papers offer thorough case documentation and in-depth information on instruments and analytical steps.

1.2 Research on drivers of and barriers to sustainability curricula implementation

One study of the EFCA project focuses on the implementation processes of sustainability curricula in higher education institutions. The core of the analysis relies on identifying specific driving and hindering factors and distinct patterns of implementation. A heterogeneity of single-case or small N comparative case studies have been published on sustainability curricula implementation processes. However, a comparison of all of the published case studies so far, and an analysis that derives generalizable results based on the single-case and small N studies, were both missing. This study helps to close this gap. In a first step, we searched widely for case studies on sustainability curricula implementation in peer-reviewed journal articles and specific edited volumes. Details on the comprehensive search strategy and further analysis of the research landscape can be found in Weiss & Barth (2019). In a second step, we built an extensive variable-based analytical scheme to compare the various case studies. To make our coding process not only understandable and transparent but also replicable, we provide the EFCA analytical scheme in this working paper.

1.3 Why an analytical scheme?

By now there is a growing but scattered body of *single-case studies* describing and/or analyzing specific sustainability curricula implementation processes in higher education institutions around the globe (Cebrián, 2017; Ferrer-Balas et al., 2008; Segovia & Galang, 2002; Trechsel et al., 2018; Velazquez, Munguia, & Sanchez, 2005; Verhulst & Lambrechts, 2015). Yet, consolidated knowledge on the role of various drivers and barriers in determining the level of sustainability curriculum implementation achieved (especially across different contexts) has been missing. As each case study is written from a different perspective (university leadership, lecturer, sustainability champion, student (occasionally), or external researcher), focuses on different variables in the description or analysis, and uses different methods to gather data, comparison is highly difficult. So how can we make use of these insights to derive evidence-based conclusions?

Barth and Thomas (2012) explain varying approaches to synthesizing case study research. In general, inter-case research aggregates data from single case studies and works toward more robust data by analyzing trends and patterns that are shared and that emerge in different contexts. These *multiple case studies and cross-comparison case studies* try to draw conclusions about the commonalities and differences among a small number of cases by using the same focus and methodology (Ferrer-Balas et al., 2008; Sterling & Scott, 2008; Junyent & Geli de Ciurana, Anna M., 2008). However, this kind of analysis can only be done for a small number of case studies.

As a single researcher isn't able to monitor and/or compare all existing case studies and research on sustainability curricula implementation processes, there is a need for an overview of existing research, one that systematically retrieves and organizes the data lying in every qualitative case study (Barth & Thomas, 2012; Fien, 2002). A more integrative interpretation of findings, i.e., one that goes beyond the findings of the single-case studies, is offered by a *meta-analytical approach*.

This research provides a unique contribution to closing this research gap by analyzing 133 case studies on sustainability curricula implementation processes around the globe by means of *the case survey method*.

The *case survey method* (Lucas, 1974; Newig & Fritsch, 2009; Yin & Heald, 1975) is a meta-analytical technique that enables researchers to "to systematically and rigorously synthesize previous case-based research by drawing on the richness of the case material, on different researchers and research designs, and at the same time allowing for a much wider generalization than from single cases" (Newig & Fritsch, 2009). To embed the case survey method in the methodological theory, Newig and Fritsch describe differences between a traditional review, a meta-synthesis, a systematic review, a meta-analysis based on qualitative (case) material—this is the case survey method—and a meta-analysis based on quantitative data. The methods differ according to the type of data input (quantitative or qualitative) and the method of integration. The categorization of the various methods in this matrix is

shown in Figure 1. The advantages of meta-analytical approaches include (first) the opportunity to analyze patterns in a large set of case studies and (second) the ability to generalize to larger populations. The number of available case studies and the restriction of information available can be seen as limitations (Barth & Thomas, 2012).

<table>
<tr><td>Source of data
Method of integration</td><td>Qualitative case studies
(unit = case)</td><td>Quantitative studies
(unit = article)</td></tr>
<tr><td>Narrative / ad hoc</td><td colspan="2">Traditional review</td></tr>
<tr><td>Qualitative, interpretive</td><td>Meta-synthesis</td><td>---</td></tr>
<tr><td>Systematic, but not quantitative</td><td colspan="2">Systematic review</td></tr>
<tr><td rowspan="2">Quantitative or otherwise highly structured (statistical or QCA)</td><td colspan="2">Meta-analysis (in a broader sense)</td></tr>
<tr><td>Case survey
(case meta-analysis)</td><td>Meta-analysis
(in the narrowest sense)</td></tr>
</table>

Figure 1: Typology of research synthesis approaches according to the used source of data and the method of integration (Newig & Fritsch, 2009)

In employing the case survey method we were guided by the steps recommended by Newig and Fritsch (2009). Figure 2 shows our procedure with its individual steps.

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 interrater reliability
9. Resolve important -but not all- coding discrepancies
10. Analyze created case data set (statistical or other)
11. Report the study

Figure 2: Case survey method steps (adapted from Newig & Fritsch, 2009)

To compare data from different case studies, the existence of a coherent and empirically operable analytical scheme (which allows for transforming the qualitative data from the case studies into quantitative data) is crucial. Regarding both the analytical scheme and the case-study reports, the analysis can be replicated by other researchers (Lucas, 1974).

In this paper, we introduce and outline an analytical scheme that was in development for over three years and was then tested in an analysis of 133 case studies from around the globe.

1.4 Applicability, scope, and development of the EFCA analytical scheme

The following analytical scheme is a first attempt at creating a rigorous procedure for comparing a large number of sustainability curricula implementation processes in higher education. This scheme was tested with 133 case studies around the globe and is meant to be applicable to all higher education institutions regardless of socio-cultural context. It allows for the analysis of sustainability curricula implementation, including the underlying mechanisms and the output of the process (i.e., the level of the sustainability curricula implementation).

The comprehensive analytical scheme is based on existing research on drivers and barriers, complemented with insights from the case studies. As a starting point, we used the logic model of drivers and barriers (Figure 3), which was compiled and structured by Barth (2015).

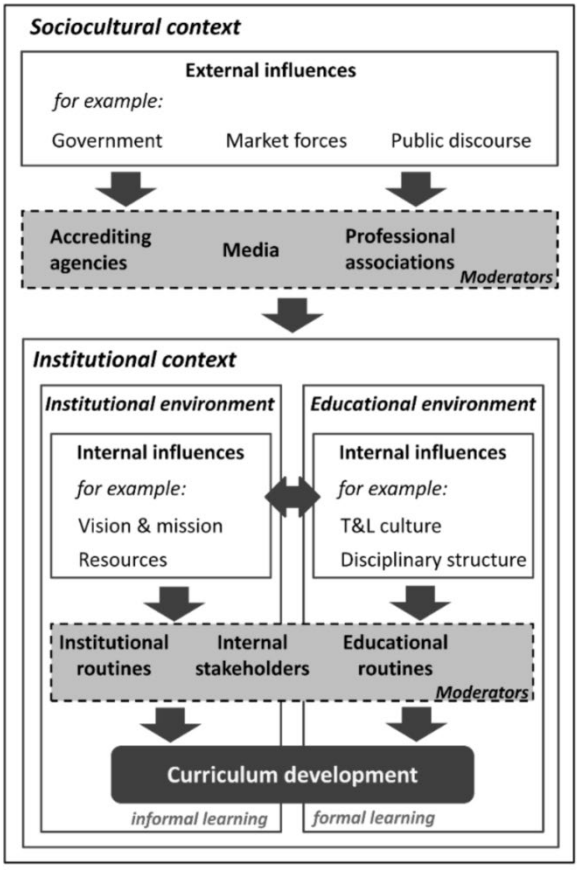

Figure 3: Layers and moderators of curriculum development (Barth, 2015)

In a second step, we supplemented the model with additional variables from the literature (Barth, 2013; Ferrer-Balas et al., 2008; Kitamura & Hoshii, 2010; Hurney et al., 2016; Thomas & Nicita, 2002; Banga Chhokar, 2010; Junyent & Geli de Ciurana, Anna M. ,2008; Velazquez, Munguia, & Sanchez, 2005; Lidgren, Rodhe, & Huisingh, 2006; Muhar, Visser, & van Breda, 2013). Finally, we tested our analytical scheme with the case study material and adapted the analytical scheme with insights drawn from this material.

To describe and analyze a sustainability curricula implementation process in a higher education institution, various drivers and barriers can be identified and described in varying degrees of detail. The overarching influence is the *sociocultural context*. Within this context are *external influences*: governmental restrictions (including relevant laws and the variability of public funding) affect the extent to which curriculum (re)development can take place, market forces apply pressure on employability of students and partially dictating the appeal of different courses of study, accrediting agencies are decisive in establishing new subjects in higher education, and public discourse impacts awareness of societal responsibility for improving the sustainability of key systems. Internally, the *institutional environment*—the institution's vision and mission (i.e., its strategic planning) as well as the resources available—is vital. For implementing innovative sustainability curricula, the *educational environment*, which includes the teaching and learning culture and the disciplinary structure (i.e., the extent of interdisciplinarity), plays a crucial role. Moreover, curriculum change is strongly connected to changes in the institution's organizational structure and the university culture: changes, that is, to institutional routines such as leadership, collaboration, and communication (Barth, 2015). An additional integral component is the support of internal stakeholders, especially academic staff and their willingness to change their teaching, university leadership offering support, and students' interest in sustainability.

In the proposed analytical scheme, we try to capture the available information at a deep and detailed level. During the coding process the following categories were used to organize the individual variables:

1. Basic data case
2. Basic data HEI (higher education institution)
3. Educational environment
4. Implementation process
5. Leadership
6. Support during the sustainability curricula implementation process
7. Internal stakeholders
8. Sociocultural context
9. Level of sustainability curricula implementation

How we situated our variables in Barth's analytical scheme is depicted in Figure 4.

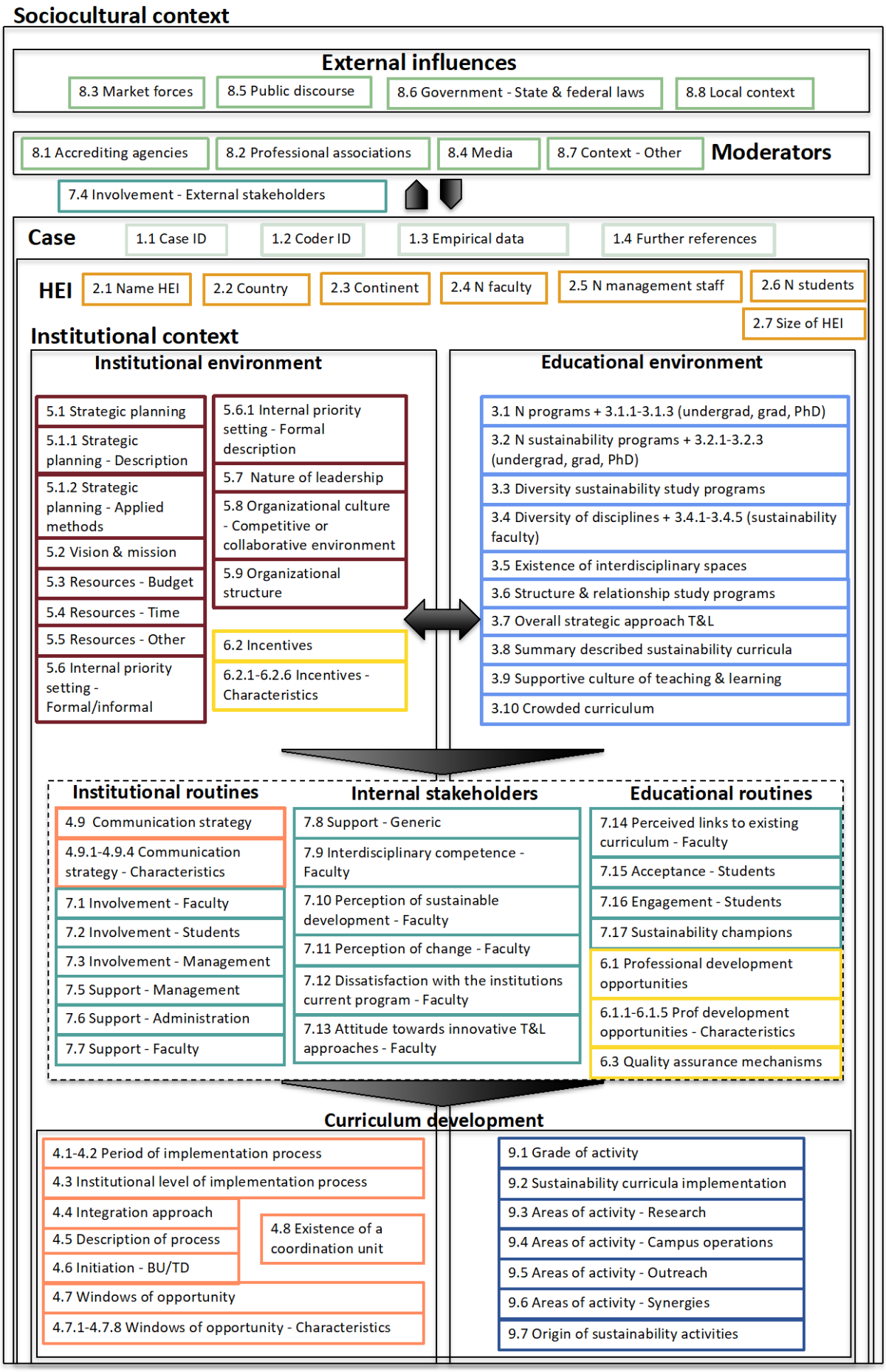

Figure 4: EFCA analytical scheme variables situated in the drivers and barriers logic model developed by Barth (2015)

1.5 Case sample description

Our unit of analysis is the higher education institution and our universe of cases consists of 133 sustainability curricula implementation processes in higher education institutions around the globe. Sources for the systematic document analysis were published peer-reviewed journal articles, chapters in specific edited volumes and additional online material from the websites of the higher education institutions. In a recently published paper (Weiss & Barth, 2019) we described our structured data collection process in detail. Overall, we found 230 case studies, which provided varying levels of information. We then analyzed the case studies using the following category structure. First, we distinguished the case studies based on their general level of information. This distinction is made by applying the *Relevance 1* and *Relevance 2* categories.

- *Relevance 1:* Case studies with at least one publication focusing on the sustainability curricula implementation process. These can be single or comparative case studies.
- *Relevance 2:* Case studies that only marginally describe the sustainability curricula implementation process. These can be single or comparative case studies.

Furthermore, we distinguished the *Relevance 1* cases based on the type of publication, as we assumed that single peer-reviewed case studies offer the most comprehensive analytical data. Therefore, we created the following categories:

- *Long:* Case studies described in depth in at least one peer-reviewed journal article and further additional publications, which could include book chapters, comparative case studies, and *Relevance 2* publications.
- *Short:* Case studies described in depth in one peer-reviewed journal article (single case study) (and no further publication.
- *Book chapter:* Case studies described in depth in a book chapter. Additional publications could include *Relevance 2* peer-reviewed articles.
- *Comparative:* Case studies included in at least one comparative study. Additional publications could include *Relevance 2* publications.

An overview of the various categories and their frequency is shown in Figure 5. Of the 230 case studies, we excluded 10 because the topic of interest wasn't captured in the published text, or because the relevant higher education institution no longer existed in the same form (e.g., it was merged with another HEI). The comprehensive database, including all collected 220 case studies structured by their relevance, publication type, name of the HEI, country, continent, and publications can be found in an open access Excel file on ResearchGate (Weiss & Barth, 2020). A shortlist with the relevance, name of the HEI, country, and continent of the case studies can be found in Appendix 1.

The proposed analytical scheme was applied to all *Relevance 1* case studies (N=133).

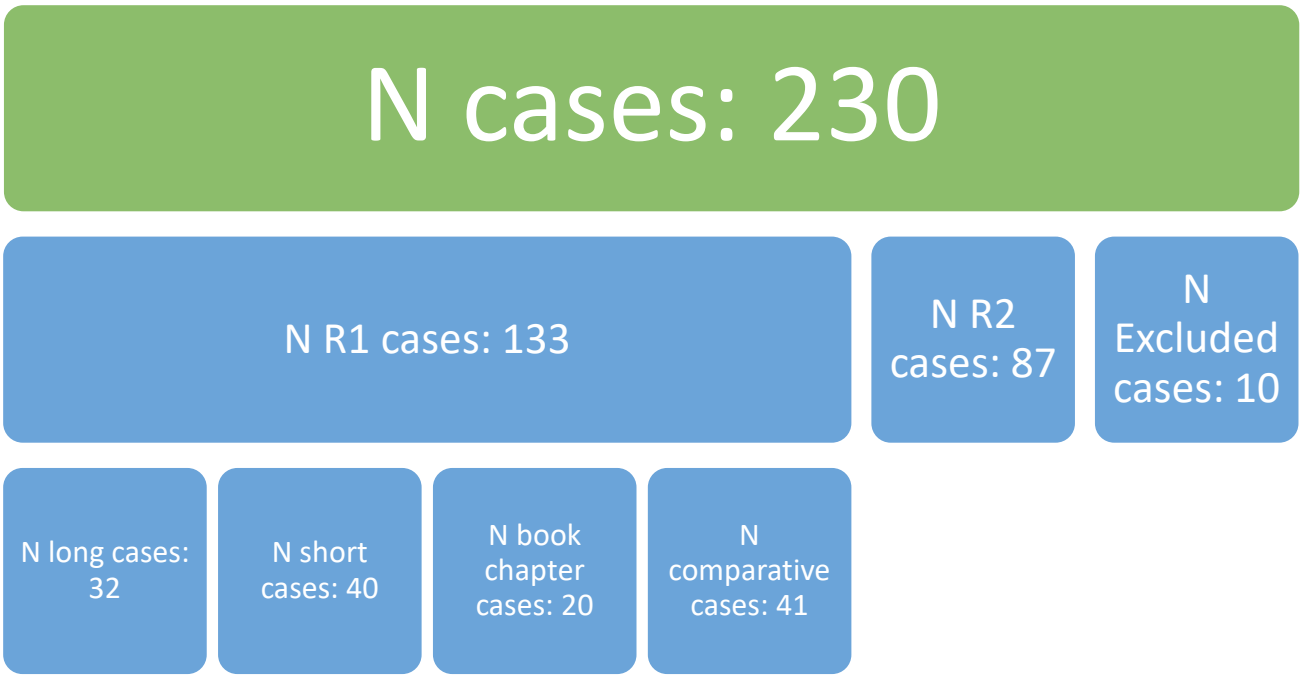

Figure 5: Frequency and structure of case studies

1.6 Acknowledgement

We thank our colleagues Jana Timm and Stephanie Jahn as well as our student and research assistants Anna Falkenstein, Franziska Steinbrügge, Johanna Kruse, Lisa Eberhardt, Lisa Eicke and Anke Klaever for helpful comments on this analytical scheme during various phases of its development and/or the collection of the case studies, which informed the development of the analytical scheme. Furthermore, we acknowledge support from the entire EFCA research team, especially from Jodie Birdman, Aaron Redman, and Arnim Wiek, who helped to clarify terms.

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Part II

The analytical scheme (Code book)

2.1 General coding guidelines

The analytical scheme consists of 111 variables and uses qualitative, categorical scaled and numeric data. To apply the analytical scheme, we recommend building a database (e.g., using an Excel spreadsheet) for all non-qualitative data. For the qualitative data, we recommend using a factsheet for each case to capture the qualitative material in greater detail. We also highly recommend using a coding protocol to capture coding decisions. This can also be recorded in the factsheets. We provide an example of a factsheet in Appendix 2.

Ideally, all variables are coded by at least two coders. In reality, there are often not enough resources to have the entirety of the case universe and all variables coded by multiple coders. In our study, two trained coders separately coded 10% of the cases; we tested the results for inter-rater agreement.

Coding should be based on evidence from the case material. In unclear cases, coders can make substantiated judgments if the variable cannot be coded otherwise. If this is the case, it is useful to make a comment in the coding protocol.

Coding should follow the coders' assessment based on the descriptions of the variables in the coding protocol and should not include any idiosyncratic interpretations or terminology introduced by the coder.

In some cases, it could be difficult to code or assess variables since the consideration of varying publications for one case, which could focus on different time spans, can result in conflicting information. Difficulties can be recorded in the coding protocol. Furthermore, some variables offer the value label "differing" to code conflicting information in the case material (i.e., different actors or publications describe the same variable either as a driver or as a barrier). Another possibility is that it is described that the variable had "some influence" and was neither a clear driver nor a barrier – in these cases the value label "medium" offers an option in-between. Both "differing" and "medium" describe the variable as an influencing factor without a clear driving or hindering impact. Which value label is used depends on the variable and our experiences in applying these to the case material.

Some variables offer an open "other" value label to make it possible to capture any information that is not captured in the named value labels. If an "other" value label is coded, a comment should be recorded in the coding protocol explaining what information is behind the "other" label.

If there is no information on the specific variable, it should be kept in mind to distinguish between the following value labels:

- **Binary variables:**
  0 = no
  1 = yes
- **Nominal variables:**
  0 = a lack of the variable is described (worked as a barrier)
  1 = the variable is described as a driver
  -77 = no information on the variable
  -99 = logically not possible due to missing information in other variable(s).

2.2 Guidelines and information for specific groups of variables

Some variables require general information, which may be looked up in other resources. The most recent data from a trustworthy resource should be used (e.g., an HEI website or annual report). These variables are marked with a **(+)** before the variable description.

- Variables 2.4 - 2.6: Number of faculty, management, students
- Variables 3.1 - 3.2.3: Number of (sustainability) programs
- Variables 3.4.1 - 3.4.5: Disciplines of the specific HEI
  - To determine whether a specific discipline is taught, inclusive and institution-wide information from the HEI's website should be included. Sources could include the pages of schools, departments, institutes, and chair levels, for example. To decide what topic belongs to which discipline it should be referred to the DFG Classification of Scientific Disciplines, Research Areas, Review Boards and Subject Areas (2016-2019).

Some variables are filter variables with related variables that give more information on the filter variable. If a filter variable is coded with -77 (no information), every related variable on a lower level should be coded with a -99 (logically not possible).

- Variable 4.7: Window of opportunity (with related characteristics: variables 4.7.1 - 4.7.8)
- Variable 4.9: Communication (with related characteristics: variables 4.9.1 - 4.9.4)
- Variable 6.1: Professional development opportunities (with related characteristics: variables 6.1.1 - 6.1.5)
- Variable 6.2: Incentives (with related characteristics: variables 6.2.1 - 6.2.6)

Some variables offer an open "other" variable to make it possible to capture any information that is not prescribed in the theoretical schemes. To indicate what information is behind the "other" label a comment in the coding protocol should be made.

- Variable 4.7.8: Window of opportunity - Characteristics: Other
- Variable 4.9.4: Communication strategy - Characteristics: Other
- Variable 5.5: Resources - Other
- Variable 6.1.5: Professional development opportunities - Characteristics: Other
- Variable 6.2.6: Incentives - Characteristics: Other

2.3 Glossary of key terms

Table 1: Glossary of key terms

Term (abbreviation)	Definition/Description
Faculty	Includes professors and all types of researchers, lecturers, and teaching assistants
Case material (CM)	Publications that report on the sustainability curricula implementation process
ESD	Education for sustainable development
HEI	Higher education institution
Management staff	Includes all non-academic staff (e.g., administrative leaders and staff)
Students	Includes all enrolled students (part-time, full-time, online)
Study programs	Includes all study programs including professional training/accompanying studies
Sustainability (-related) programs	Programs that point to sustainability based on the title/name or description of the program: at least one form of the word *sustainab** must be mentioned at some point. Exclude single courses, certificates, and minors. Exclude programs that are described solely as environmental
T&L	Teaching and learning
Top management staff	Includes HEI president (institution level), deans and associates (division level), program leaders

2.4 Key abbreviations and symbols

Table 2: Key abbreviation and symbols

(+)	Besides the case material, other external sources like the website or annual report of the HEI may be consulted
-77	No information
-99	Logically not possible
bin.	Binary scale
met.	Metric scale
nom.	Nominal scale
ord.	Ordinal scale
qual.	Qualitative scale

2.5 List of scales used

Table 3: List of scales used

Scale	Coding possibilities	Missing information
[0/1]	0,1	-77/-99
[0..2]	0,1,2	-77/-99
[0..3]	0,1,2,3	-77/-99
[0..4]	0,1,2,3,4	-77/-99
[1..3]	1,2,3	-77
[1..4]	1,2,3,4	-77/-99
[1..5]	1,2,3,4,5	-77
[1..7]	1,2,3,4,5,6,7	-77
Number	Enter numbers	-77/-99
Text	Enter text	-77/-99
Date	Enter date YYYY	-77

Note: the choice to include multiple scales with the same number of assignable values (e.g. 0..2 and 1..3 each have three possible value designations) is deliberate. Due to our logic model, which we chose because it enables us to describe barriers and drivers, a value of 0 is assigned if anything is described as a barrier/weak/lack of (etc.). Categories that do not admit of a barrier/driver assessment are scaled beginning with 1. If you are not working within a barrier/driver model, you may be tempted to simplify the coding scheme and start every scale with 0. We would gently encourage you not to do this, as it could be barrier to later comparative or collaborative research on studies coded by different teams.

2.6 How to read the tables

The Codebook consists of 5 columns:

1. Numeration of each category or variable.
2. Name and abbreviation of the variable.
3. Data type: We use the following data types: qualitative (text), binary (no/yes), metric (number), ordinal (categories in a specific order), nominal (categories without a specific order), and date.
4. Value label: Description of the kind of data that can be coded. "Text" indicates that you can insert text-based data. If the data type is binary, ordinal, or nominal the range of possible value labels is given. For instance, [1..6] means that you can code a 1, 2, 3, 4, 5, or 6. Moreover, guidance is provided on how to code missing data. A -77 indicates that the data is not available, and a -99 indicates that the coding is not logically possible due to a filter variable.
5. Description of the variable. If applicable, the value labels are described. Moreover, further notes to specify inclusion or exclusion criteria, or coding rules are explained to eliminate conflicts during coding.

Table 4: Explanation of table structure for the code book

X.	**Name of the Category**			
X.1	Variable name (Abbreviation)	Data type	Value label	Description of the variable. Description of value labels (if applicable). *Further notes on exclusion/inclusion criteria or coding rules (if applicable)*
Example 1				
1.1	Case identification (CASE ID)	qual.	Text	Continuous numeration (three-digit) of selected case studies from the population (e.g., C001).
Example 2				
2.7	Size HEI (SIZE HEI)	ord.	[1..4]	Current size of institution. 1 ≥ 30,000 students 2 ≥ 12,000 students 3 ≥ 5,000 students 4 < 5,000 students *Note: The number of students from variable 2.6 N students should be used to code this variable.*

2.7 Variables Category 1: Basic Data Case

1.	BASIC DATA CASE			
1.1	**Case identification** **(CASE ID)**	qual.	Text	Continuous numeration (three-digit) of selected case studies from the population (e.g., C001).
1.2	**Coder ID** **(CODER ID)**	qual.	Text	Initials of coder.
1.3	**Empirical data** **(EMP DATA)**	bin.	[0/1]	Statement of whether empirical evidence is used in at least one publication. 0 = no 1 = yes
1.4	**Further references** **(REF)**	bin.	[0/1]	Statement of whether further references are mentioned in the case material that offer more information on the implementation process of sustainability curricula at the specific HEI. 0 = no 1 = yes *Note: The explicit qualitative text string is marked in MAXQDA for possible further analysis.*

2.8 Variables Category 2: Basic Data HEI

2.	BASIC DATA HEI			
2.1	**Name HEI** **(NAME HEI)**	qual.	Text	Full name of the higher education institution (HEI) in English. If there is no English name, the common name used in the country in which the HEI is located should be used. The abbreviation should be placed in parentheses.
2.2	**Country** **(COUNTRY)**	qual.	Text	Name of the country in which the HEI is located.
2.3	**Continent** **(CONTINENT)**	nom.	[1..6]	Name of the continent in which the HEI is located. 1=Africa 2=Asia 3=Europe 4=Latin America and the Caribbean 5=North America 6=Oceania and Australia *Note: The detailed number of cases per country and the affiliated region based on the UN geographical regions (United Nations (UN), 2018).*
2.4	**Number of faculty** **(N FACULTY)**	met.	Number -77	**(+)** Current number of faculty. *Note: If the numbers of faculty and administrative or management staff cannot be disentangled, the overall staff number should be coded under N faculty, and a note should be made in the coding protocol.*
2.5	**Number of management staff** **(N MGMT)**	met.	Number -77	**(+)** Current number of management staff. *Note: This figure should be excluded if the numbers of academic and administrative or management staff cannot be separated. The overall staff number should be coded under variable 2.4 N Faculty, and a note should be made in the coding protocol.*

2.	**BASIC DATA HEI *(continued)***			
2.6	**Number of students** **(N STUDENTS)**	met.	Number -77	**(+)** Current number of students.
2.7	**Size HEI** **(SIZE HEI)**	ord.	[1..4]	Current size of institution. 1 ≥ 30,000 students 2 ≥ 12,000 students 3 ≥ 5,000 students 4 < 5,000 students *Note: The number of students from variable 2.6 N students should be used to code this variable.*

2.9 Variables Category 3: Educational Environment

3.	EDUCATIONAL ENVIRONMENT			
3.1	**Number of all programs** **(N PROGRAMS ALL)**	met.	Number -77 -99	**(+)** Number of all study programs. *Note: Exclude single courses, minors, certificates. Code based on the variables 3.1.1, 3.1.2, 3.1.3 and add up the numbers. If one of these numbers is missing, code it with -99.*
3.1.1	**Number of undergrad programs** **(N PROGRAMS UNDERGRAD)**	met.	Number -77	**(+)** The current number of all bachelor's degree programs. *Note: Exclude single courses, minors, certificates.*
3.1.2	**Number of grad programs** **(N PROGRAMS GRAD)**	met.	Number -77	**(+)** The current number of all master's degree programs. *Note: Exclude single courses, minors, certificates.*
3.1.3	**Number of doctoral programs** **(N PROGRAMS DR)**	met.	Number -77	**(+)** The current number of all PhD programs. *Note: Exclude single courses, minors, certificates.*
3.2.	**Number of all sustainability programs** **(N SUS PROGRAMS ALL)**	met.	Number -77 -99	**(+)** Number of all sustainability-related study programs. *Note: Exclude single courses, certificates, minors. Code based on the variables 3.2.1, 3.2.2, 3.2.3 and add up the numbers. If one of these numbers is missing, code it with -99.*
3.2.1	**Number of undergrad sustainability programs** **(N SUS PROGRAMS UNDERGRAD)**	met.	Number -77	**(+)** The current number of all sustainability-related bachelor's degree programs. *Note: Exclude single courses, certificates, minors.*

3.	EDUCATIONAL ENVIRONMENT *(continued)*			
3.2.2	**Number of grad sustainability programs** **(N SUS PROGRAMS GRAD)**	met.	Number -77	**(+)** The current number of all sustainability-related master's degree programs. *Note: Exclude single courses, certificates, minors.*
3.2.3	**Number of doctoral sustainability programs** **(N SUS PROGRAMS DR)**	met.	Number -77	**(+)** The current number of all sustainability-related PhD programs. *Note: Exclude single courses, certificates, minors.*
3.3	**Diversity sustainability study programs** **(DIV SUS PROGRAMS)**	ord.	[0..2] -77 -99	Description of the diversity of sustainability study programs in terms of the degree(s) offered (undergrad, Master's, PhD). 0 = weak diversity (one type of degree [undergrad, grad, or PhD] is offered) 1 = medium diversity (two types of degree are offered) 2 = high diversity (all three types of degree are offered) *Note: Include the codings of the variables 3.2.1-3.2.3 as a data source.*
3.4	**Diversity of disciplines** **(DIV DISC)**	ord.	[0..2] -77 -99	Description of the diversity of disciplines taught. 0 = weak diversity (1-2 disciplines are taught) 1 = medium diversity (3 are taught) 2 = high diversity (4 are taught) *Note: Include the codings of the variables 3.4.1-3.4.4 as a data source. Exclude Variable 3.4.5. Diversity of disciplines: Sustainability.*

3.	EDUCATIONAL ENVIRONMENT *(continued)*			
3.4.1	**Diversity of disciplines - Humanities & social sciences** **(DISC HUM SOC)**	bin.	[0/1] -77	**(+)** Statement of whether humanities or social sciences are part of the taught disciplines. 0 = no 1 = yes
3.4.2	**Diversity of disciplines - Natural sciences** **(DISC NAT)**	bin.	[0/1] -77	**(+)** Statement of whether natural sciences are part of the taught disciplines. 0 = no 1 = yes
3.4.3	**Diversity of disciplines - Life sciences** **(DISC LIFE SC)**	bin.	[0/1] -77	**(+)** Statement of whether life sciences are part of the taught disciplines. 0 = no 1 = yes
3.4.4	**Diversity of disciplines - Engineering** **(DISC ENG)**	bin.	[0/1] -77	**(+)** Statement of whether engineering is part of the taught disciplines. 0 = no 1 = yes
3.4.5	**Diversity of disciplines - Sustainability sciences** **(DISC SUS)**	bin.	[0/1] -77	**(+)** Statement of whether sustainability science is part of the taught disciplines. 0 = no 1 = yes *Note: include if the discipline is taught at the HEI and criteria for identifying disciplines are inclusive and institution-wide. These could be based, for example, on faculties, schools, departments, institutes, chair levels. Include if "sustainab*" is mentioned in the name of the faculty, institute, chair, center etc.*

3.	EDUCATIONAL ENVIRONMENT *(continued)*			
3.5	**Existence of interdisciplinary spaces** **(INTERDISC SPACE)**	nom.	[0..3] -77	Description of whether interdisciplinary collaborations, meetings, workshops, or other forms of disciplinary cooperation exist as a constant part of teaching and learning practices. 0 = lack of, described as a barrier 1 = differing 2 = yes, described as a driver 3 = other *Note: include constant (regular and institutionalized, not just occasional) interdisciplinary collaborations and spaces, for example, interdisciplinary centers that teach. Sustainability collaborations (if constant and part of teaching and learning practice) are also classified as interdisciplinary spaces. Exclude one-time workshops (for instance, a few interdisciplinary workshops during a research project or a few interdisciplinary meetings).*
3.6	**Structure & relationship of study programs** **(STRCTR STUDY P)**	nom.	[0..2] -77	Description of whether courses/programs/modules exist in which students from different disciplines can enroll. 0 = lack of 1 = yes 2 = other

3.	**EDUCATIONAL ENVIRONMENT *(continued)***			
3.7	**Overall strategic approach to teaching & learning** **(TLA OVERALL)**	qual.	Text -77	**(+)** Description of the *generic* teaching & learning approach of the HEI. The teaching and learning approach means information on general principles and pedagogy used for instruction. In general, it could be student-centered, or teacher-centered. Examples of approaches are discursive learning, solution-oriented learning, consultative learning, experiential learning, problem-based learning, project-based learning. Some examples of format: teacher as a facilitator, group-works, collaboration, innovative methods, project-based learning, reflection, lecture, videos, online learning, stakeholder engagement. *Note: include information that is extracted from the vision or mission of the HEI's website and the case material (CM). Exclude individual (just for one course or by one teacher) teaching and learning approaches.*
3.8	**Summary described sustainability curricula** **(SUM DESCRBD CURRI)**	qual.	Text -77	Brief description of the sustainability curriculum mentioned in the case material. This includes a) the offering type (one course, program, curricula, training); b) the target audience (students, faculty, stakeholders, other); c) the degree granted by the sustainability curriculum (BA, MA, PhD, faculty training, certificate, other); d) the name(s) of the described sustainability curricula; e) the applied teaching and learning approach; f) the learning objectives (e.g., sustainability competencies); g) the program structure.

3.	EDUCATIONAL ENVIRONMENT *(continued)*			
3.9	**Supportive culture of teaching and learning** **(SUPP CLT TL)**	nom.	[0..3] -77	Assumption of the existence of a supportive culture of teaching and learning (T&L) within the higher education institution. This includes openness to innovation, supportive structures to encourage innovation, participatory approaches to decision-making. The culture of T&L may be described in terms of the institutional, academic, or professional culture. 0 = weak (lack of supportive culture is explicitly mentioned as a barrier in the text—for instance, missing incentives for innovation, no academic freedom, no participation) 1 = medium/differing (supportive culture is not explicitly stressed in the text, but the text hints at incentives for one or some but not all elements—for instance, innovative T&L or participatory decision-making) 2 = high (supportive culture is mentioned as an important driver and explicitly stressed in the text—for instance, support for innovative T&L methods are mentioned, participatory decision-making is in place) 3 = other (supportive culture is mentioned as an important driver and explicitly stressed in the text, but it is stated generically and it remains unclear what the institution really does to create a supportive culture of T&L)
3.10	**Crowded curriculum** **(CROW CURR)**	nom.	[0..3] -77	Description of whether a dense curriculum, already full of other topics, is described as an influence affecting sustainability curricula implementation. 0 = yes, described as a barrier 1 = differing 2 = no crowded curriculum, described as driver 3 = other

2.10 Variables Category 4: Implementation Process

4.	IMPLEMENTATION PROCESS			
4.1	**Period of sustainability curricula implementation process - Start** **(PERIOD SCIP START)**	date	Date -77	Description of the start date of the sustainability curricula implementation process. Format: YYYY *Note: if different periods are mentioned make a note in the coding protocol and use the earliest date.*
4.2	**Period of sustainability curricula implementation process - End** **(PERIOD SCIP END)**	date	Date -77	Description of the end date of the sustainability curricula implementation process. Format: YYYY *Note: if different periods are mentioned make a note in the coding protocol and use the latest date.*
4.3	**Institutional level of the sustainability curricula implementation process** **(INSTITUTIONAL LEVEL SCIP)**	nom.	[1..5] -77	Description of the institutional level (whole HEI, division (e.g., faculty, school, center), program, course) of the sustainability curricula implementation process that is described. 1 = institution 2 = division (e.g., faculty/school/center level) 3 = program 4 = course 5 = other *Note: code the highest mentioned level of the described process. For instance, if the institutional level is the focus of the study, but a single course is described too, code it as 1. Special case: one compulsory undergrad ESD course for all disciplines counts as institution-wide.*

4.	IMPLEMENTATION PROCESS *(continued)*			
4.4	**Integration approach of the sustainability curricula implementation process** **(INTEGRATION APRCH SCIP)**	nom.	[1..7] -77	Description of the approach to implementing sustainability curricula in the HEI. 1 = integration of sustainability as a minor subject in existing course(s) 2 = integration of sustainability as a minor subject in existing program(s) 3 = integration of sustainability in a minor 4 = new (re)design of program(s) (offering a major) focused on sustainability 5 = general studies approach—integration of sustainability as a subject in different parts in university curricula 6 = creation of new sustainability department (chairs, institutes etc. are included) 7 = other
4.5	**Description of the sustainability curricula implementation process** **(DESCRIP SCIP)**	qual.	Text	Brief description of the sustainability curricula implementation process. The focus is on the nature of the process, activities that foster sustainability curricula implementation, temporal occurrence of the variables (drivers and barriers), and synergies. Capture a) all phases with time periods (include notes about the initial situation), b) all highlighted variables (drivers and barriers) and in which phase they were important, c) the grade of activity per phase and whether these were successful; d) the internal priority-setting and whether it changed during the process (capture time period); e) planned improvements.

4.	IMPLEMENTATION PROCESS *(continued)*			
4.6	**Initiation - Bottom-up/top-down** **(INI BU/TD)**	nom.	[1..3] -77	Description of whether the sustainability curricula implementation process started at the "bottom" (students, academic staff) or the "top" (top management). 1 = bottom-up 2 = top-down 3 = other *Note: "top-down" is excluded if the management executes the implementation but the process was initiated at the level of students or academic staff (the bottom).*
4.7	**Window of opportunity** **(WOO)**	nom.	[0..3] -77	Description of whether a favorable opportunity or momentum fostered the sustainability curricula implementation process. 0 = lack of, described as a barrier 1 = differing 2 = yes, described as a driver 3 = other
4.7.1	**Window of opportunity - Characteristics: Forthcoming accreditation processes** **(WOO ACCRED)**	bin.	[0/1] -77 -99	Statement of whether a forthcoming accreditation fostered the sustainability curricula implementation process. 0 = lack of, described as missing 1 = yes
4.7.2	**Window of opportunity - Characteristics: Change of faculty (WOO CHG FACULTY)**	bin.	[0/1] -77 -99	Statement of whether a change of staff fostered the sustainability curricula implementation process. 0 = lack of, described as missing 1 = yes

4.	IMPLEMENTATION PROCESS *(continued)*			
4.7.3	**Window of opportunity - Characteristics: Change of top-management** **(WOO CHG TM)**	bin.	[0/1] -77 -99	Statement of whether a change of top management fostered the sustainability curricula implementation process. 0 = lack of, described as missing 1 = yes
4.7.4	**Window of opportunity - Characteristics: State support** **(WOO STATE SPT)**	bin.	[0/1] -77 -99	Statement of whether an external political guideline or a support program promoted the implementation of sustainability curricula. 0 = lack of, described as missing 1 = yes
4.7.5	**Window of opportunity - Characteristics: Requirement to restructure HEI (extern)** **(WOO RESTRUCTURE)**	bin.	[0/1] -77 -99	Statement of whether there was an external requirement to restructure the HEI (regardless of whether the requirement was sustainability-focused) that fostered the sustainability curricula implementation process. For instance, restructuring of the HEI because it was financially precarious. 0 = lack of, described as missing 1 = yes
4.7.6	**Window of opportunity - Characteristics: Evaluation/reform of programs (intern)** **(WOO EVAL)**	bin.	[0/1] -77 -99	Statement of whether any kind of internal evaluation or reform fostered the sustainability curricula implementation process. 0 = lack of, described as missing 1 = yes
4.7.7	**Window of opportunity - Characteristics: Political reforms** **(WOO POL REFORM)**	bin.	[0/1] -77 -99	Statement of whether an external political reform fostered the sustainability curricula implementation process. For instance, Bologna reform in HEIs located in Europe. 0 = lack of, described as missing 1 = yes

4.	**IMPLEMENTATION PROCESS *(continued)***			
4.7.8	**Window of opportunity - Characteristics: Other** **(WOO O)**	bin.	[0/1] -77 -99	Statement of whether any other kind of favorable opportunity fostered the sustainability curricula implementation process. For instance, special (limited) funding, a research project, changes in local context (e.g., restructuring). 0 = lack of, described as missing 1 = yes
4.8	**Existence of a coordination unit** **(COORDINATION)**	nom.	[0..3] -77	Description of whether some type of a coordination unit is formed at the HEI to organize the activities required to implement sustainability curricula. The coordination unit can be individual persons, a steering committee or digital platforms responsible for organizing the activities, or simply a platform for keeping track of the activities with no assigned responsibility. 0 = lack of, described as a barrier 1 = medium/differing 2 = yes, described as a driver 3 = other *Note re. an atypical example: a specific coordination unit isn't created, but coordination is stressed in another context, e.g., a strategic plan is implemented, which contains explicit provision for the implementation of sustainability curricula.*

4.	**IMPLEMENTATION PROCESS *(continued)***			
4.9	**Communication strategy** **(COMM)**	nom.	[0..3] -77	Description of whether some type of an internal verbal or visual communication strategy (exchange of information between a sender and a receiver) is executed to spread information about the implementation of sustainability curricula to trigger a process of learning that happens within the institution. For instance, mailing lists, internal information campaigns, points of contact, specific books or materials about how to implement sustainability education. Digital types are included. 0 = lack of, described as a barrier 1 = differing/in place but unclear impact 2 = yes, described as a driver 3 = other *Note re. an atypical example: a participation process during the action research method, but also used intentionally to spread the vision; a collaborative approach to develop sustainability curricula (stakeholder involvement); methods for outreach e.g., a collaborative scheme.*
4.9.1	**Communication strategy - Characteristics: Information campaign** **(COMM CAMPAIGN)**	bin.	[0/1] -77 -99	Statement of whether an information campaign (effort to educate a large number of individuals and boost public awareness over a specific time) was used as a communication strategy to foster the implementation of sustainability curricula. 0 = lack of, described as missing 1 = yes
4.9.2	**Communication strategy - Characteristics: Involvement of diff. stakeholders** **(COMM INVOLV STAKEH)**	bin.	[0/1] -77 -99	Statement of whether the communication strategy of the HEI was targeted to different stakeholder groups (internal/external) to foster the implementation of sustainability curricula. 0 = lack of, described as missing 1 = yes

4.	IMPLEMENTATION PROCESS *(continued)*			
4.9.3	**Communication strategy - Characteristics: Point of contact** **(COMM CONTACT POINT)**	bin.	[0/1] -77 -99	Statement of whether a specific point of contact (e.g., specific contact persons, a center for ESD, a coordination unit) was used as a communication strategy to foster the implementation of sustainability curricula. 0 = lack of, described as missing 1 = yes
4.9.4	**Communication strategy - Characteristics: Other** **(COMM O)**	bin.	[0/1] -77 -99	Statement of whether any other kind of communication strategy (internal and external) was used to foster the implementation of sustainability curricula, e.g., a website (or, less typically, lobbying). 0 = lack of, described as missing 1 = yes

2.11 Variable Category 5: Leadership

5.	LEADERSHIP			
5.1	**Strategic planning (STRAT PLAN)**	nom.	[0..3] -77	Description of whether a systematic process (strategic planning) with objectives and steps for achieving some level of sustainability curricula implementation is in place. 0 = lack of, described as a barrier 1 = medium/differing 2 = yes, described as a driver 3 = other
5.1.1	**Strategic planning - Description** **(STRAT PLAN DESCRIP)**	qual.	Text -77 -99	Description of the specific systematic process (strategic planning) with the objectives and steps intended to achieve (any level of) sustainability curricula implementation. Take notes a) on the implementation strategies mentioned; b) on methods that were used; c) on special variables that are highlighted, e.g., motivation or engagement strategies.
5.1.2	**Strategic planning - Applied methods for implementing change process** **(STRAT PLAN METHOD)**	qual.	Text -77 -99	Description of the methods that were used during the sustainability curricula implementation process, e.g., evaluation tools, assessment, etc.

5.	LEADERSHIP *(continued)*			
5.2	**Vision & mission** **(VISION)**	nom.	[0..3] -77	**(+)** Description of whether sustainability education or sustainability is represented in the HEI's vision, mission, charter, or a comparable source. 0 = not mentioned in vision 1 = mentioned in vision, which is available online 2 = mentioned in vision, which is available online and described as a driver in case material (CM) 3 = other (e.g., mentioned in case material, but not available online) *Note: include information from the case material and the HEI's website or annual report.*
5.3	**Resources - Budget** **(RES BUDGET)**	nom.	[0..3] -77	Description of whether money and budgeting influences sustainability curricula implementation. 0 = lack of budget, described as a barrier 1 = differing 2 = enough budget, described as a driver 3 = other
5.4	**Resources - Time** **(RES TIME)**	nom.	[0..3] -77	Description of whether time influences sustainability curricula implementation. For example, it is described that time affected formal planning, evaluation, reporting processes, and adding sustainability issues to curriculum. 0 = lack of time, described as a barrier 1 = differing 2 = extra time, described as a driver 3 = other

5.	**LEADERSHIP *(continued)***			
5.5	**Resources - Other** **(RES O)**	nom.	[0..3] -77	Description of whether resources other than money or time (e.g., human resources or other resources) influence sustainability curricula implementation. Include if human or generic resources are described without details relating to what kind of resources affected formal planning, evaluation, reporting processes, and adding sustainability issues to curriculum. 0 = lack of resources 1 = differing 2 = enough resources 3 = other *Note re. an atypical example: academic workload (as it not solely refers to time, but also to mental resources)*

5.	LEADERSHIP *(continued)*			
5.6	**Internal priority setting - Formal/informal** **(INT PRIORITY FRML/INFRML)**	nom.	[0..3] -77	Description of the strategic planning and prioritization of sustainability curricula; i.e., whether ESD is operationalized in some official manifestation within the HEI, as well as how the strategic planning and prioritization of sustainability curricula is executed within the HEI. Official manifestations include, e.g., mission statements, official policies, declarations, sustainability or environmental plans, guidelines, learning outcome guidelines for a whole institution or division, etc. (can be on university or unit level). 0 = lack of formalization 1 = differing (formalization, but weak informal priority setting) 2 = yes, formalization 3 = other (could be, for example, no information about formal, but weak or strong informal support) *Note: exclude individual course or program-level learning outcomes (PLOs) that focus on ESD; these are coded under variable 3.8 Summary described sustainability curricula.*
5.6.1	**Internal priority setting - Formal description** **(INT PRIORITY FRML DESCRIP)**	qual.	Text -77 -99	Description of what official manifestations exist that express the strategic planning and prioritization of sustainability curricula within the HEI. For instance, mission statements, official policies, declarations, sustainability or environmental plans, guidelines, learning outcome guidelines for the whole institution or division etc. (can be on university or unit level). *Note: exclude individual course and program-level learning outcomes (PLOs) that focus on ESD; these are coded under variable 3.8 Summary described sustainability curricula.*

5.	LEADERSHIP *(continued)*			
5.7	**Nature of leadership** **(LEADERSHIP)**	nom.	[0..3] -77	Description of the nature of leadership (top management) in terms of supporting the implementation of sustainability curricula. Leadership involves the establishment of a clear vision, communication strategies to share the vision and provide information, methods to realize the vision, and coordination to execute the implementation of sustainability curricula. 0 = weak leadership (no support, no interest, no awareness) 1 = inconsistent leadership (changes in the top management, different phases, changing priorities, vision but no strategy) 2 = strong leadership (strong support, e.g., vision, strategic planning, incentives) 3 = other
5.8	**Organizational culture - Competitive or collaborative environment** **(COLL ENVRNMT)**	nom.	[0..3] -77	Description of the organizational culture (expectations, experiences, philosophy, values that hold the organization together: in other words, shared attitudes) of the HEI in terms of a competitive or a collaborative atmosphere. 0 = barrier (the competitive environment of the organization is described as a barrier or the collaboration needs to be strengthened) 1 = medium/differing (some or differing efforts to work collaboratively, but not described as a barrier) 2 = driver (the collaborative environment of the organization is described as a driver) 3 = other

5.	LEADERSHIP *(continued)*			
5.9	**Organizational structure** **(ORG STRCT)**	nom.	[0..3] -77	Description of the generic organizational structure and its influence affecting the sustainability curricula implementation process. For instance, descriptions of "silos" or "ivory towers" or academic traditions as barriers. 0 = lack of structure, described as a barrier 1 = differing 2 = sufficient (changed) structure, described as a driver 3 = other

2.12 Variable Category 6: Support mechanisms

6.	SUPPORT MECHANISMS			
6.1	**Professional development opportunities** **(PROF DEVELOP)**	nom.	[0..3] -77	Description of whether mechanisms to assist or encourage sustainability curricula implementation are in place, providing and/or distributing high-level knowledge (provided by HEI). 0 = lack of, described as a barrier 1 = medium/differing 2 = yes, described as a driver 3 = other (e.g., if professional development opportunities are used in the research method of the paper)
6.1.1	**Professional development opportunities - Characteristics: Faculty training** **(PROF DEVELOP FCLTY TRNG)**	bin.	[0/1] -77 -99	Description of whether faculty training (provided by the HEI) was used as one method to support staff in carrying out the implementation of sustainability curricula. 0 = lack of, described as missing 1 = yes
6.1.2	**Professional development opportunities - Characteristics: Individual coaching** **(PROF DEVELOP INDVL COACH)**	bin.	[0/1] -77 -99	Description of whether individual coaching was used as one method to support staff in carrying out the implementation of sustainability curricula. 0 = lack of, described as missing 1 = yes
6.1.3	**Professional development opportunities - Characteristics: Spaces for exchange of expertise (group, network)** **(PROF DEVELOP SPACE)**	bin.	[0/1] -77 -99	Description of whether specific physical spaces for exchange of expertise exist as one method to support staff in carrying out the implementation of sustainability curricula. 0 = lack of, described as missing 1 = yes

6.	SUPPORT MECHANISMS *(continued)*			
6.1.4	**Professional development opportunities - Characteristics: Good teaching practices** **(PROF DEVELOP GTP)**	nom.	[0..2] -77 -99	Description of whether examples of good teaching practices (materials, not persons) exist as one method to support staff in carrying out the implementation of sustainability curricula. 0 = lack of, described as missing 1 = yes
6.1.5	**Professional development opportunities - Characteristics: Othe** **(PROF DEVELOP O)**	nom.	[0..2] -77 -99	Description of whether any kind of method other than those mentioned above exist to support staff in carrying out the implementation of sustainability curricula. 0 = lack of, described as missing 1 = yes
6.2	**Incentives** **(INCTIV)**	nom.	[0..3] -77	Description of whether any kind of incentive is created to motivate and encourage people (academics, faculty, students, and external stakeholders) to engage in the sustainability curricula implementation process. 0 = lack of, described as a barrier 1 = medium/differing 2 = yes, described as a driver 3 = other
6.2.1	**Incentives - Characteristics: Awards (intern)** **(INCTIV INT AWRD)**	bin.	[0/1] -77 -99	Statement of whether internal awards are created as incentives to motivate and encourage people to engage in the sustainability curricula implementation process. For instance, awards for innovative teaching and learning approaches. 0 = lack of, described as missing 1 = yes

6.	SUPPORT MECHANISMS *(continued)*			
6.2.2	**Incentives - Characteristics: Awards (extern)** **(INCTIV EXT AWRD)**	bin.	[0/1] -77 -99	Statement of whether external awards (governmental, local companies etc.) exists or are created as incentives to motivate and encourage people to engage in the sustainability curricula implementation process. 0 = lack of, described as missing 1 = yes
6.2.3	**Incentives - Characteristics: Financial** **(INCTIV FINANCE)**	bin.	[0/1] -77 -99	Statement of whether financial incentives (e.g., raises or bonuses) are offered to motivate and encourage people to engage in the sustainability curricula implementation process. 0 = lack of, described as missing 1 = yes
6.2.4	**Incentives - Characteristics: Time** **(INCTIV TIME)**	bin.	[0/1] -77 -99	Statement of whether time advantages are offered as incentives to motivate people to engage in the sustainability curricula implementation process. For instance, a reduction of regular working hours to have more time for working on implementing sustainability curricula. 0 = lack of, described as missing 1 = yes
6.2.5	**Incentives - Characteristics: Promotion** **(INCTIV PROMO)**	bin.	[0/1] -77 -99	Statement of whether a promotion (e.g., granting tenure) is offered as an incentive to encourage people to engage in the sustainability curricula implementation process. 0 = lack of, described as missing 1 = yes
6.2.6	**Incentives - Characteristics: Other** **(INCTIV O)**	bin.	[0/1] -77 -99	Statement of whether any other kind of incentive besides those mentioned above is offered to motivate and encourage people to engage in the sustainability curricula implementation process. 0 = lack of, described as missing 1 = yes

6.	SUPPORT MECHANISMS (*continued)*			
6.3	**Quality assurance mechanisms** **(QAM)**	nom.	[0..4] -77	Description of whether any kind of mechanisms or systems are in place to check the quality of sustainability education. Include evaluations, e.g., checking the content of courses/programs/curricula with the aim of ensuring or improving consistency with ESD. 0 = lack of (no quality assurance mechanisms are established) 1 = occasional/differing (some sort of quality assurance mechanisms are occasionally applied, but not on a regular basis) 2 = established (quality assurance mechanisms are constant and established, meaning they are institutionalized and have allocated resources) 3 = research method (quality assurance mechanisms are used as a research method in the case studies, but it is unclear if they are institutionalized) 4 = other

2.13 Variable Category 7: Internal Stakeholders

7.	INTERNAL STAKEHOLDERS			
7.1	**Involvement - Faculty** **(INVOLV FACULTY)**	nom.	[0..3] -77	Description of how faculty take part in the sustainability curricula implementation process in terms of expressing and registering their opinions, participation in decision-making, initiation or support of the sustainability curricula implementation process. 0 = lack of 1 = formal (participation led by the university) 2 = informal (personal initiative) 3 = other (e.g., involvement through research method) *Note: exclude initiatives of single persons.*
7.2	**Involvement - Students** **(INVOLV STUDENTS)**	nom.	[0..3] -77	Description of how students take part in the sustainability curricula implementation process in terms of expressing and registering their opinions, participation in decision making, initiation or support of the sustainability curricula implementation process. 0 = lack of 1 = formal (participation led by the university) 2 = informal (personal initiative) 3 = other *Note: exclude initiatives of single persons and student involvement in research projects or campus sustainability initiatives.*

7.	INTERNAL STAKEHOLDERS *(continued)*			
7.3	**Involvement - Management** **(INVOLV MGMT)**	nom.	[0..3] -77	Description of how management staff take part in the sustainability curricula implementation process in terms of expressing and registering their opinions, participation in decision-making, initiation or support of the sustainability curricula implementation process. 0 = lack of 1 = formal (participation led by the university) 2 = informal (personal initiative) 3 = other *Note: exclude initiatives of single persons.*
7.4	**Involvement - External stakeholders** **(INVOLV EXT STAKEH)**	nom.	[0..3] -77	Description of how individuals or organizations not part of the HEI take part in the sustainability curricula implementation process in terms of expressing and registering their opinions, participation in decision-making, initiation or support of the sustainability curricula implementation process. 0 = lack of 1 = formal (participation led by the university) 2 = informal (personal initiative) 3 = other *Note: exclude initiatives of single persons.*
7.5	**Support - Management** **(SUPP MGMT)**	nom.	[0..3] -77	Description of the commitment, willingness, and motivation of top management staff to steer and promote sustainability curricula implementation. 0 = no support, described as a barrier 1 = medium/differing support 2 = high support, described as a driver 3 = other

7.	INTERNAL STAKEHOLDERS *(continued)*			
7.6	**Support - Administration** **(SUPP ADMIN)**	nom.	[0..3] -77	Description of the commitment, willingness and motivation of administration to steer and promote sustainability curricula implementation. 0 = no support, described as a barrier 1 = medium/differing support (e.g., if support from administration is described, but bureaucracy is also mentioned as a challenge) 2 = high support, described as a driver 3 = other (e.g., if bureaucracy is described as a challenge)
7.7	**Support - Faculty** **(SUPP FACULTY)**	nom.	[0..3] -77	Description of the commitment, willingness and motivation of faculty to steer and promote sustainability curricula implementation. 0 = no support, described as a barrier 1 = medium/differing support 2 = high support, described as a driver 3 = other
7.8	**Support - Generic** **(SUPP GNRC)**	nom.	[0..3] -77	Description of the commitment, willingness, and motivation of nonspecific stakeholders to steer and promote sustainability curricula implementation. For instance, if it is described that the sustainability curricula implementation was widely accepted. 0 = no support (explicitly mentioned) 1 = differing support (positive and negative support explicitly mentioned) 2 = high support (explicitly mentioned) 3 = other

7.	INTERNAL STAKEHOLDERS *(continued)*			
7.9	**Interdisciplinary competence - Faculty** **(INTERDIS COMP FACULTY)**	nom.	[0..3] -77	Description of faculty's understanding of sustainability-related topics and ability to teach these topics. 0 = lack of competence, described as a barrier 1 = medium/differing competence 2 = high competence, described as a driver 3 = other *Note re. an atypical example: A lack of shared understandings or shared language to discuss sustainability topics.*
7.10	**Perception of sustainable development - Faculty** **(PERC SD FACULTY)**	nom.	[0..3] -77	Description faculty's beliefs and opinions regarding sustainable development generally and the implementation of sustainability curricula specifically. 0 = negative perception, barrier 1 = medium/differing perception 2 = positive perception, driver 3 = other (e.g., if there are differing perceptions regarding the different dimensions) *Note re. an atypical example: differing attitudes regarding differing sustainability dimensions (e.g., positive perception of ecological sustainability, but negative perception of social sustainability).*
7.11	**Perception of change - Faculty (PERC CHNG FACULTY)**	nom.	[0..3] -77	Description of faculty's general opinion on and willingness to accept change. 0 = negative perception, barrier 1 = differing perception 2 = positive perception, driver 3 = other

7.	INTERNAL STAKEHOLDERS *(continued)*			
7.12	**Dissatisfaction with the institutions current program - Faculty** **(DISSAT FACULTY)**	nom.	[0..3] -77	Description of faculty's dissatisfaction with the institution's current program. 0 = no dissatisfaction, described as a barrier 1 = differing, not described as a driver 2 = high dissatisfaction, described as a driver 3 = other
7.13	**Attitude towards innovative T&L approaches - Faculty** **(ATT ITL FACULTY)**	nom.	[0..3] -77	Description of the attitude toward innovative teaching and learning (T&L) approaches of faculty. 0 = negative attitude, barrier 1 = medium/differing attitude 2 = positive attitude, driver 3 = other *Note: include not just the overall culture, but also individual cases. If it is only mentioned on an individual level, place a comment in the coding protocol.*
7.14	**Perceived links to existing curriculum - Faculty** **(PERC CURR LINKS FACULTY)**	nom.	[0..3] -77	Description of perceived links between sustainability as a topic (or different sustainability dimensions) to the existing curriculum as an influence on the implementation of sustainability curricula by faculty. 0 = negative perception, described as a barrier 1 = medium/differing perception 2 = positive perception, described as a driver 3 = other *Note: include not just an overall culture, but also individual cases.*

7.	INTERNAL STAKEHOLDERS *(continued)*			
7.15	**Acceptance - Students** **(ACC STUDENTS)**	nom.	[0..3] -77	Description of student awareness and acceptance of sustainability programs in terms of requesting and supporting such an implementation and/or by enrolling in such curricula. 0 = no acceptance, described as a barrier 1 = medium/differing acceptance 2 = high acceptance, described as driver 3 = other
7.16	**Engagement - Students** **(ENGAGE STUDENTS)**	nom.	[0..3] -77	Description of the students' engagement regarding sustainability curriculum change. 0 = lack of 1 = yes, leads to curriculum change 2 = yes, but ineffective (does not lead to curriculum change) 3 = other (e.g., engagement in campus sustainability initiatives)
7.17	**Sustainability champions** **(SUS CHAMP)**	nom.	[0..3] -77	Description of whether sustainability champions (individuals that really shape sustainable development, transformative leaders) actively steer sustainability curricula change. This could be single persons, small groups, or evolving groups (could be students, faculty, or other stakeholders). 0 = lack of, described as a barrier 1 = medium 2 = yes, described as a driver 3 = other

2.14 Variable Category 8: Sociocultural Context

8.	SOCIOCULTURAL CONTEXT			
8.1	**Accrediting agencies** **(ACCRED A)**	nom.	[0..3] -77	Description of the influence of accrediting agencies on sustainability curricula implementation. Accrediting agencies include all external organizations responsible for accrediting studies or quality assessment (these could be, e.g., governmental or industry-based). 0 = none, described as a barrier 1 = medium 2 = yes, described as a driver 3 = other (e.g., if some influence/involvement is planned)
8.2	**Professional associations** **(PROF ASSOC)**	nom.	[0..3] -77	Description of the influence of external organizations that articulate the voices of employers and alumni (professional associations) on sustainability curricula implementation. 0 = none, described as a barrier 1 = medium 2 = yes, described as a driver 3 = other (e.g., if some influence/involvement is planned)
8.3	**Market forces** **(MARKET F)**	nom.	[0..3] -77	Description of the influence of market forces on sustainability curricula implementation. Market forces include, for example, calls from industries and employers regarding output-orientation, competence development, and employability. 0 = none, described as a barrier 1 = medium 2 = yes, described as a driver 3 = other (e.g., if some influence/involvement is planned)

8.	SOCIOCULTURAL CONTEXT *(continued)*			
8.4	**Media** **(MEDIA)**	nom.	[0..3] -77	Description of the influence of any kind of media on sustainability curricula implementation. 0 = none, described as a barrier 1 = medium 2 = yes, described as a driver 3 = other (e.g., if some influence/involvement is planned)
8.5	**Public discourse** **(PUB DISC)**	nom.	[0..3] -77	Description of the influence of public discourse (discussion of sustainability issues within the society) on sustainability curricula implementation. For instance, sustainability problem awareness within society. 0 = none, described as a barrier 1 = medium 2 = yes, described as a driver 3 = other (e.g., if some influence/involvement is planned)
8.6	**Government - State & federal laws** **(GOVERNM)**	nom.	[0..3] -77	Description of the influence of the government on sustainability curricula implementation. For instance, specific laws or boundaries, in which development may or may not take place (e.g., ESD is mandated for all Engineering undergrad degrees), or the influence of local municipalities or ministries, are mentioned. 0 = none, described as a barrier 1 = medium 2 = yes, described as a driver 3 = other

8.	**SOCIOCULTURAL CONTEXT *(continued)***			
8.7	**Context - Other** **(CONTEXT O)**	qual.	Text	Description of the influence of other external factors or stakeholders (other than accrediting agencies, professional associations, media, market forces, government, public discourse) on sustainability curricula implementation. For instance, NGOS, networks, partnerships, peer institutions or top-tier universities may serve as examples to promote sustainability curricula implementation. *Note re. an atypical example: documents (including governmental guidelines etc.) are used to inspire the HEI's own ESD strategy. If some influence/involvement is planned, make a note in the coding protocol.*
8.8	**Local context** **(LOCAL CTXT)**	qual.	Text	Brief description of factors in the local/regional context (geography, societal/ecological problems, history, surrounding city/town) that influence the sustainability curricula implementation process. For instance, water issues, cultural traditions, globalization, climate destabilization, newness of higher education, autonomy of institutions, development of an institution in a specific local context.

2.15 Variable Category 9: Level of Sustainability Curricula Implementation

9.	LEVEL OF SUSTAINABILITY CURRICULA IMPLEMENTATION			
9.1	**Grade of activity (GOA)**	ord.	[1..3] -77	Description of the level of activity in terms of time relating to sustainability curricula implementation efforts. 1 = recently started activities, meaning for <5y 2 = established activities, meaning for 5-10y 3 = long tradition of activities, meaning >10y *Note: in most cases the timespan of the available publications refers to a specific earlier stage of the implementation process. We assume that the process is still ongoing (often depictable through the HEI's current annual reports or websites). To compare all cases, we decided to use the year in which we started the coding as an anchor point to estimate the time span. Example: If variable 4.1 Period of sustainability curricula implementation process -Start is coded as 2008, and we started our coding process in 2018, then we look back at ten years of implementation (=established activities).*

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9.	LEVEL OF SUSTAINABILITY CURRICULA IMPLEMENTATION *(continued)*			
9.2	**Sustainability curricula implementation (RATING SUS IMPLEMENTATION)**	nom.	[0..3]	Rating of the sustainability curricula development within the HEI in terms of the approach of Sterling and Thomas (2006), which holds that sustainability curricula development can happen on a spectrum of different levels and depths. Sterling and Thomas differentiate between denial (no change), bolt-on (education about sustainability), build-in (education for sustainability), and curriculum redesign (sustainability education) (Sterling & Thomas, 2006). 0 = no change 1 = bolt-on (Sustainability issues inform disciplinary topics with the integration of sustainability into existing courses or program(s).) 2 = build-in (Sustainability is tackled via interdisciplinary collaboration with the creation of a new discipline or cross-disciplinary sustainability courses or programs. Or, ESD is at least in HEI's current vision (HEI's annual report or website) plus in ESD courses/programs.) 3 = redesign (Sustainability issues are integrated into common core requirements and/or the vision—case material (earlier stage – depends on publication date) and online (current state)—of the HEI. In addition, there has to be medium or strong leadership support.)

9.	LEVEL OF SUSTAINABILITY CURRICULUM DEVELOPMENT *(continued)*			
9.3	**Areas of activity - Research** **(GOA RESEARCH)**	ord.	[0..3] -77	Description of the level of activity and effort (not success) in terms of commitment to the area of sustainability research. 0 = no specific activities 1 = active (the area is mentioned, but is not the focus of the HEI) 2 = significant (the commitment becomes visible in projects, initiatives etc.) 3 = core focus (the commitment becomes visible in projects, initiatives etc., and the commitment is determined in strategic papers, vision etc.)
9.4	**Areas of activity - Campus operations** **(GOA CAMPUS)**	ord.	[0..3] -77	Description of the level of activity and effort (not success) in terms of commitment to campus sustainability. For instance, information on energy, waste, and sustainability management systems. 0 = no specific activities 1 = active (the area is mentioned, but is not the focus of the HEI) 2 = significant (the commitment becomes visible in projects, initiatives etc.) 3 = core focus (the commitment becomes visible in projects, initiatives etc., and the commitment is determined in strategic papers, vision etc.)

9.	LEVEL OF SUSTAINABILITY CURRICULA IMPLEMENTATION *(continued)*			
9.5	**Areas of activity - Outreach** **(GOA OUTREACH)**	ord.	[0..3] -77	Description of the level of activity in terms of sustainability outreach. Include activities that connect research and other activities of the HEI to society and specific communities, e.g., partnerships with local communities to support sustainable development. 0 = no specific activities 1 = active (the area is mentioned, but is not the focus of the HEI) 2 = significant (the commitment becomes visible in projects, initiatives etc.) 3 = core focus (the commitment becomes visible in projects, initiatives, etc., and the commitment is determined in strategic papers, vision etc.)
9.6	**Areas of activity - Synergies** **(GOA SYN)**	ord.	[0..2] -77	Description of the level of activity and effort (not success) in terms of fostering ESD through building interactions or cooperation between teaching and learning (T&L), research, campus operations, and outreach, which produces a combined effect greater than the sum of their separate effects. 0 = no specific synergies 1 = some synergies are described 2 = synergies are pushed
9.7	**Origin of sustainability activities** **(GOA ORIGIN)**	nom.	[1..5] -77	Description of the activity that started other sustainability activities. 1 = research 2 = teaching & learning 3 = campus operations 4 = outreach 5 = other

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Appendix

No. 1 Case study lists structured by their relevance

Relevance 1 case studies (N=133)

Table 5: Relevance 1 case studies

Continent	Country	Name of the Higher Education Institution
Africa	Botswana	University of Botswana (UB)
Africa	South Africa	Rhodes University
Africa	Tanzania	University of Dar es Salaam
Asia	China	Beijing Normal University (BNU)
Asia	China	Tsinghua University
Asia	India	Anna University
Asia	India	Indira Gandhi Open National University (IGOU)
Asia	India	Jadavpur University
Asia	India	Jammu University
Asia	India	Symbiosis International University
Asia	India	TERI University
Asia	India	University of Hyderabad
Asia	India	University of Madras
Asia	India	University of Pune
Asia	Indonesia	Universitas Gadjah Mada (UGM)
Asia	Iran	Amirkabir University of Technology (AUT)
Asia	Japan	Hokkaido University
Asia	Japan	Ibaraki University
Asia	Japan	Kobe University
Asia	Japan	Kyoto University
Asia	Japan	Osaka University
Asia	Japan	Shinshu University (SU)
Asia	Japan	University of Tokyo
Asia	Malaysia	National University of Malaysia
Asia	Malaysia	University Sains Malaysia (USM)
Asia	Oman	Sultan Qaboos University
Asia	Philippines	Miriam College
Asia	South-Korea	Yonsei University (YU)
Asia	Thailand	Asian Institute of Technology (AIT)
Asia	Vietnam	Hanoi National University of Education (HNUE)
Asia	Vietnam	Ho Chi Minh University of Pedagogy (HCMUP)
Asia	Vietnam	Hue University of Education (HUEd)
Asia	Vietnam	Quang Nam University (QNU)
Asia	Vietnam	University of Da Nang, Danang University of Education (DUEd)

Continent	**Country**	**Name of the Higher Education Institution** *(continued)*
Europe	Bulgaria	University of Architecture, Civil Engineering and Geodesy (UACEG)
Europe	Denmark	Aalborg University
Europe	Germany	Leuphana University
Europe	Germany	University of Tübingen
Europe	Greece	University of Aegean
Europe	Greece	University of Thessaloniki
Europe	Latvia	Daugavpils University
Europe	Latvia	Liepaja University (LiepU)
Europe	Latvia	Rezekne Higher Education Establishment (RHEE)
Europe	Latvia	University of Latvia
Europe	Netherlands	Delft University of Technology (DUT)
Europe	Netherlands	Eindhoven University
Europe	Netherlands	Erasmus University of Rotterdam
Europe	Netherlands	Van Hall Larenstein University of Applied Science
Europe	Spain	Technical University of Catalonia (UPC)
Europe	Spain	Technical University of Valencia (TUV)
Europe	Spain	University of Zaragoza
Europe	Sweden	Chalmers University of Technology
Europe	Sweden	KTH Royal Institute of Technology
Europe	Sweden	Linköping University
Europe	Sweden	Lund University
Europe	Switzerland	ETH Zurich
Europe	Switzerland	Zurich University of Applied Sciences
Europe	UK	Anglia Ruskin University
Europe	UK	Bournemouth University
Europe	UK	Cambridge University
Europe	UK	De Montfort University
Europe	UK	Newcastle University
Europe	UK	University of Bristol
Europe	UK	University of Gloucestershire
Europe	UK	University of Huddersfield
Europe	UK	University of Leeds
Europe	UK	University of Plymouth
Europe	UK	University of Southampton
Europe	UK	University of Strathclyde
Europe	UK	University of the West of England
Europe	UK	University of Wales Trinity Saint David
Latin America and the Caribbean	Brazil	Methodist University of São Paulo (Universidade Metodista de São Paulo (UMESP))
Latin America and the Caribbean	Ecuador	Universidad Técnica del Norte
Latin America and the Caribbean	Jamaica	University of the West Indies
Latin America and the Caribbean	Mexico	Metropolitan Autonomous University

Continent	Country	Name of the Higher Education Institution *(continued)*
Latin America and the Caribbean	Mexico	Monterrey Institute of Technology and Higher Education
Latin America and the Caribbean	Mexico	National Autonomous University of Mexico
Latin America and the Caribbean	Mexico	Universidad Veracruzana
Latin America and the Caribbean	Mexico	University of Sonora
North America	Canada	Bishop's University
North America	Canada	British Columbia Institute of Technology
North America	Canada	Dalhousie University
North America	Canada	Université de Sherbrooke
North America	Canada	University of Alberta
North America	Canada	University of British Columbia (UBC)
North America	Canada	University of Guelph
North America	Canada	York University
North America	USA	Arizona State University (ASU)
North America	USA	Berea College
North America	USA	California State University, Northridge (CSUN)
North America	USA	Carnegie Mellon University
North America	USA	Emory University
North America	USA	Ferrum College
North America	USA	Florida Gulf Coast University
North America	USA	George Washington University
North America	USA	Indiana University Bloomington
North America	USA	Ithaca College
North America	USA	James Madison University (JMU)
North America	USA	Johns Hopkins
North America	USA	Middlebury College
North America	USA	Northern Arizona University
North America	USA	Ohio State University (OSU)
North America	USA	Philadelphia University
North America	USA	Princeton
North America	USA	San José State University
North America	USA	Tulane University
North America	USA	Unity College
North America	USA	University of California, Santa Cruz (UCSC)
North America	USA	University of Colorado Boulder
North America	USA	University of Hawaii
North America	USA	University of Minnesota
North America	USA	University of New Hampshire
North America	USA	University of New Haven
North America	USA	University of Northern Iowa
North America	USA	University of Pennsylvania (Penn)
North America	USA	University of South Carolina
North America	USA	University of Utah

Continent	Country	Name of the Higher Education Institution *(continued)*
North America	USA	University of Vermont (UVM)
North America	USA	Yale
Oceania and Australia	12 Islands Nation	University of the South Pacific
Oceania and Australia	Australia	Deakin University
Oceania and Australia	Australia	Edith Cowan University
Oceania and Australia	Australia	James Cook University (JCU)
Oceania and Australia	Australia	La Trobe University
Oceania and Australia	Australia	Monash University
Oceania and Australia	Australia	Murdoch University
Oceania and Australia	Australia	Oceania and Australian Catholic University
Oceania and Australia	Australia	Oceania and Australian National University (ANU)
Oceania and Australia	Australia	Royal Melbourne Institute of Technology (RMIT) University
Oceania and Australia	Australia	University of New South Wales
Oceania and Australia	Australia	University of South Oceania and Australia
Oceania and Australia	Australia	University of Tasmania
Oceania and Australia	Australia	University of Technology (UTS)
Oceania and Australia	Australia	University of Wollongong

Relevance 2 case studies (N=87)

Table 6: Relevance 2 case studies

Continent	Country	Name of Higher Education Institution
Africa	South Africa	Stellenbosch University
Africa	South Africa	University of South Africa (UNISA)
Asia	China	Tongji University
Asia	India	Apeejay School of Management
Asia	Israel	Green Valley College
Asia	Jordan	Amman University
Asia	Jordan	Hashemite University
Asia	Lebanon	Notre Dame University
Asia	Malaysia	University Malaysia Sarawak
Asia	Thailand	Maejo Universities
Asia	Turkey	Bilkent University
Europe	Austria	BOKU University
Europe	Austria	University of Graz
Europe	Czech Republic	Technical University of Ostrava
Europe	Denmark	Roskilde University
Europe	Denmark	Royal Veterinary and Agricultural University
Europe	Denmark	University of Copenhagen
Europe	Germany	University of Applied Sciences Zittau/Goerlitz
Europe	Germany	University of Paderborn
Europe	Greece	University of Thessaly

Continent	Country	Name of the Higher Education Institution *(continued)*
Europe	Ireland	St Angela's College
Europe	Ireland	University of Limerick
Europe	Italy	Polytechnic University of Milan
Europe	Italy	University of Milano-Bicocca
Europe	Lithuania	Kaunas University of Technology
Europe	Netherlands	University of Amsterdam
Europe	Netherlands	Vrije Universiteit Amsterdam (VU)
Europe	Netherlands	Zeeland University of Applied Sciences (ZU)
Europe	Russia	St Petersburg State University
Europe	Sweden	Blekinge Institute of Technology (BTH)
Europe	Turkey	Bogazici University
Europe	UK	Canterbury Christ Church University
Europe	UK	Keele University
Europe	UK	Manchester Metropolitan University (MMU)
Europe	UK	Middlesex University
Europe	UK	The University of Nottingham
Europe	UK	University of Bradford
Europe	UK	University of Chester
Europe	UK	University of Leicester
Europe	UK	University of Manchester
Europe	UK	University of Surrey
Europe	UK	University of Worcester
Europe	UK	University of X
Latin America and the Caribbean	Brazil	Paulista University
Latin America and the Caribbean	Jamaica	Bethlehem Moravian College
Latin America and the Caribbean	Jamaica	Edna Manley College of the Visual and Performing Arts
Latin America and the Caribbean	Jamaica	Moneague College
Latin America and the Caribbean	Jamaica	St. Joseph's Teachers' College (SJTC)
North America	Canada	Brock University
North America	Canada	Laval University
North America	Canada	Olds College
North America	Canada	Ryerson University
North America	Canada	Simon Fraser University (SFU)
North America	Canada	University of Prince Edward Island
North America	Canada	University of Toronto
North America	Canada	University of Victoria
North America	USA	Appalachian State University
North America	USA	City College of New York
North America	USA	Clemson University
North America	USA	Colorado State University
North America	USA	Cornell University

Continent	**Country**	**Name of the Higher Education Institution** *(continued)*
North America	USA	Georgia Institute of Technology
North America	USA	Green Mountain College
North America	USA	Hobart & William Smith Colleges (HWS)
North America	USA	Kettering University
North America	USA	Michigan State University
North America	USA	Northland College
North America	USA	Oklahoma State University
North America	USA	Pennsylvania State University
North America	USA	Portland State University
North America	USA	Salisbury University
North America	USA	San Diego State University
North America	USA	Tufts University
North America	USA	University of Alaska Fairbanks
North America	USA	University of Arizona
North America	USA	University of Delaware
North America	USA	University of Guam
North America	USA	University of Michigan
North America	USA	University of Oklahoma
North America	USA	University of Texas-Pan American (UTPA)
Oceania and Australia	Australia	Charles Sturt University
Oceania and Australia	Australia	Curtin University
Oceania and Australia	Australia	Griffith University
Oceania and Australia	Australia	Queensland University of Technology (QUT)
Oceania and Australia	Australia	Southern Cross University
Oceania and Australia	Australia	University of Sydney
Oceania and Australia	New Zealand	Victoria University of Wellington

No. 2 Factsheet – Example

FACT SHEET

Case ID:

HEI name:

Coder ID:

Date(s) of Coding*:

Note: please include all dates separated by commas

VARIABLE	NOTES
1.4 Further references **(REF)**	
3.8 Summary described sustainability curricula **(SUM DESCRBD CURRI)** ***Take notes on the information described below**. You don't have to describe it in this order, just be sure to capture information on all the factors described below. If something. seems very important or if it helps to structure the information, please underline the selected text or format the text in **bold**.* *- **Described level** (one course, program, curricula, training)* *- **Target audience** (students, faculty, stakeholders, other)* *- **Degree(s)** of the mentioned sustainability curricula (BA, MA, PhD, faculty training, certificate, other)* *- **Name(s) of the described sustainability curricula*** *- **Applied teaching and learning approach and methods** (see also Codebook 3.8)* *- **Learning objectives** (e.g. sustainability competencies* *- **Program structure***	

4.5 Description of the sustainability curricula implementation process **(DESCRIP SCIP)** *Brief description of the implementation process for the sustainability curricula.* ***Take notes on ALL information about the implementation process, e.g. the information described in the bullet points**. You don't have to describe it in this order, just be sure to capture all information about the factors described below **with enough context information!** Don't summarize too much; you can copy/paste passages from the case study. If something seems very important or if it helps to structure the information, please underline the selected text or format the text in **bold**.* *- **All phases with time scales** (include notes about the **initial situation**)* *- **All emphasized variables** (drivers and barriers) and in which phase they were important* *- **Grade of activity** (active, significant, core focus) per phase and whether these were successful* *- **Internal priority setting** and whether it changed during the process (capture timescale/phase)* *- **Planned improvements*** *- **Figures** if provided by the case study (include figures at the end of the table with a reference in this cell)*	
5.1.1 Strategic planning - Description **(STRAT PLAN DESCRIP)**	

Description of the specific systematic process (strategic planning) ***intended to achieve any level (even small-scale improvements) of sustainability curricula implementation, with all objectives and steps described.*** ***Take notes on all information regarding strategy aimed at fostering ESD, e.g., information on the bullet points described below****. You don't have to describe it in this order, just be sure to capture all information regarding the factors described below. If something seems very important or if it helps to structure the information, please underline the selected text or format the text in* ***bold****.* *-* ***Implementation strategies*** *mentioned, e.g., a sustainability plan with different steps* *-* ***Special variables*** *that were emphasized, e.g., motivation or engagement strategies.* *-* ***Figures*** *if provided by the case study (include figures at the end of the table with a reference in this cell)*	
5.1.2 Strategic planning - Applied methods for implementing change process **(STRAT PLAN METHOD)** *Description of the methods that were used during the* ***sustainability curricula implementation process*** *(e.g., evaluation tools, assessment, action-research etc.)*	
8.8 Local context **(LOCAL CTXT)**	

Brief description of factors in the local/regional context (geography, societal/ecological problems, history, surrounding city/town/geopolitical context/traditions etc.) that influence the sustainability curricula implementation process.	
ADDITIONAL NOTES	
Other important notes about the case **- Your impression of the case study.** What would you tell me in one sentence about it, if I haven't read it and want to know specifics about the implementation strategy and its drivers/barriers. **-Everything that seems important to you but isn't captured in the variables.**	
Coding protocol **Please make notes on your coding decisions for EVERY variable.** You can copy/paste text passages on which you base your decisions to make your point clear. If unsure how to code an item, please state the problem and discuss it with the other coders.	

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Back cover

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10.6 Appendix No. 6: Descriptive Report (Paper 2, 3)

Weiss, M., & Barth, M. (2020). 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.

Available at https://bit.ly/EFCA-DescriptiveReportOnAnalyticalScheme

Descriptive Statistical Report on the EFCA Analytical Scheme on Sustainability Curricula Implementation Processes in Higher Education Institutions

Marie Weiss, Matthias Barth

LEUPHANA
UNIVERSITÄT LÜNEBURG

Educating Future Change Agents

Descriptive statistical report on the EFCA analytical scheme on sustainability curricula implementation processes in higher education institutions:

Marie Weiss, Center for Global Sustainability and Cultural Transformation, Faculty of Sustainability, Leuphana University of Lüneburg, Lüneburg, Niedersachsen, Germany
marie.weiss@leuphana.de

Matthias Barth, Center for Global Sustainability and Cultural Transformation and Institute for Integrative Studies, Leuphana University of Lüneburg, Lüneburg, Niedersachsen, Germany
matthias.barth@leuphana.de

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UNIVERSITY OF LÜNEBURG

ASU Arizona State University

Funded By:

Niedersächsisches Ministerium für Wissenschaft und Kultur

VolkswagenStiftung

Editorial

This descriptive statistical report provides additional material on publications within the study *Sustainability Curricula Implementation Processes in Higher Education Institutions* of the **Educating Future Change Agents Research Project (EFCA)**. Its main objective is to make related information available in a transparent fashion which usually exceeds the scope of journal articles. Fellow researchers, scholars and practitioners are invited to comment, discuss and contribute their thoughts and own experiences.

Related journal articles & published material:

Weiss, Marie; Barth, Matthias (2019): Global research landscape of sustainability curricula implementation in higher education. International Journal of Sustainability in Higher Education 20 (4), 570-589. DOI: 10.1108/IJSHE-10-2018-0190.

Weiss, Marie; Barth, Matthias (2020): Comparative Analysis of Sustainability Curricula Implementation Processes in Higher Education Institutions: A Variable-based Analytical scheme. Working Papers in Higher Education for Sustainable Development, No. 1/2020). Leuphana University Lüneburg, Center for Global Sustainability and Cultural Transformation, ISSN (online) 2700-6735.

Weiss, Marie; Barth, Matthias (2020): Comparative analysis of sustainability curricula implementation processes in higher education institutions: A list of case studies that went into the analysis (N=230). Leuphana University Lüneburg. DOI: 10.13140/RG.2.2.16894.33606. Available at https://bit.ly/EFCA-CaseUniverse.

Weiss, Marie; Barth, Matthias; Wiek, Arnim; von Wehrden, Henrik (forthcoming): Drivers and Barriers of Implementing Sustainability Curricula in Higher Education – Assumptions and Evidence.

Weiss, Marie; Barth, Matthias; von Wehrden, Henrik (forthcoming): The patterns of curriculum change processes that embed sustainability in higher education institutions.

Published: **April 4. 2020**
Version 2: September 7. 2020

Please cite as:

Weiss, Marie; Barth, Matthias (2020): 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. Available at https://bit.ly/EFCA-DescriptiveReportOnAnalyticalScheme.

Table of Contents

Introduction

1.1 The Educating Future Change Agents Project

The *Educating Future Change Agents* (EFCA) project produced empirical insights on how higher education can support student development of key competencies in sustainability. The research was conducted jointly by Leuphana University of Lüneburg, Germany and Arizona State University, Tempe, Arizona, USA from 2016 to 2020. The project comprised five studies, each of which included in-depth case studies and comparative studies at the course, curriculum, and institutional level. Cases were selected to ensure a high degree of both similarity and variance within and across cases and to represent the widely recognized fields of sustainability education, namely, education of sustainability professionals, teachers, and entrepreneurs.

All studies were grounded in a single analytical scheme that informed both data collection and analysis. Based on this scheme, each study adopted its own suite of research methods (methods appropriate to the relevant research questions) while still coordinating and sharing insights on methods among the studies. Each study produced a set of results specific to the case(s) and contexts studied. In the final phase of the project, results from the individual studies were synthesized into general insights useful for researchers, educators, and administrators in the field of sustainability education.

Results of the EFCA project have been widely published and can be found on ResearchGate: https://www.researchgate.net/project/Educating-Future-Change-Agents. This working paper series provides previously unpublished background material and additional information with the aim of facilitating greater understanding of the research that was carried out. It is our ambition to be as transparent as possible, offering thorough case documentation and in-depth information on the instruments and analytical steps we undertook.

1.2 Research on drivers and barriers to implement sustainability curricula

One sub-project of the EFCA project focuses on the implementation processes of sustainability curricula in higher education institutions. The core of the analysis relies on identifying specific driving and hindering factors and distinct patterns of implementation. A heterogeneity of single-case or small N comparative case studies have been published on sustainability curricula implementation processes. However, a comparison of all of the published case studies so far, and an analysis that derives generalizable results based on the single-case and small N studies, were both missing. This sub-projects of the EFCA project helps to close this gap. In a first step, we searched widely for case studies on sustainability curricula implementation in peer-reviewed journal articles and specific edited volumes. Details on the comprehensive search strategy and further analysis of the research landscape

can be found in Weiss & Barth (2019) [1]. In a second step, we built an extensive variable-based analytical scheme to compare the various case studies. To make our coding process not only understandable and transparent but also replicable, we provide the EFCA analytical scheme in a working paper (Weiss & Barth 2020)[2]. For the final analysis, we used various quantitative and qualitative methods. Key drivers and barriers were addressed with frequency analysis and chi-square statistics. Distinctive patterns were detected by cluster analysis. All results were accompanied and verified by referring back to the qualitative material using summaries, content analysis, and constant comparison.

This descriptive statistical report directly related to the analytical scheme is published in the aforementioned working paper, and provides additional material and insights into the variables in a transparent way.

[1] Weiss, Marie; Barth, Matthias (2019): Global research landscape of sustainability curricula implementation in higher education. International Journal of Sustainability in Higher Education 20 (4), 570-589. DOI: 10.1108/IJSHE-10-2018-0190.

[2] Weiss, Marie; Barth, Matthias (2020): Comparative analysis of sustainability curricula implementation processes in higher education institutions: A variable-based analytical scheme. Working Papers in Higher Education for Sustainable Development, No. 1/2020. Leuphana University Lüneburg, Center for Global Sustainability and Cultural Transformation, ISSN (online) 2700-6735.

Descriptive statistics

2.1 How to read this descriptive report

In our statistical analysis we structured the variables along nine categories. The development of the analytical scheme (code book) is described in Weiss and Barth (2020)[2], where one can also find definitions and value labels for each variable. To make the most out of this statistical report we strongly recommend referring back to that analytical scheme (code book).

In this report we present the variables according to the structure provided in the analytical scheme. Each category is described in a separate table in order according to the analytical scheme. Categorical variables are first described in each category, complemented by frequency bar plots, and followed by the descriptive statistics of the metric variables. Summaries of text-based variables are not provided due to the extensive quantity and individual character of the data.

2.2 Variable Category 1: Basic Data Case

1.	BASIC DATA CASE			
Nr.	**Variable name**	**Value label**	**Frequency**	**Percent**
1.3	Empirical data	no	54	40.6
		yes	79	59.4
1.4	Further references	no	57	42.9
		yes	76	57.1

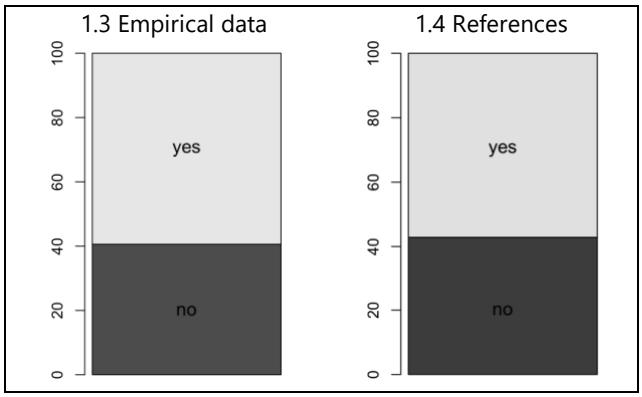

Figure 1 Frequency bar plots (in percent) of category: Basic Data Case – based on 133 case studies on sustainability curricula implementation processes in higher education institutions around the globe

2.3 Variable Category 2: Basic Data HEI

2.	**BASIC DATA HEI** – Categorical variables			
Nr.	**Variable name**	**Value label**	**Frequency**	**Percent**
2.2	Country	12 Pacific Island Nations	1	0.75
		Botswana	1	0.75
		Brazil	1	0.75
		Bulgaria	1	0.75
		Denmark	1	0.75
		Ecuador	1	0.75
		Indonesia	1	0.75
		Iran	1	0.75
		Jamaica	1	0.75
		Oman	1	0.75
		Phillippines	1	0.75
		South Africa	1	0.75
		South Korea	1	0.75
		Tanzania	1	0.75
		Thailand	1	0.75
		China	2	1.5
		Germany	2	1.5
		Greece	2	1.5
		Malaysia	2	1.5
		Switzerland	2	1.5
		Spain	3	2.3
		Latvia	4	3.0
		Netherlands	4	3.0
		Sweden	4	3.0
		Mexico	5	3.8
		Vietnam	5	3.8
		Japan	7	5.3
		Canada	8	6.0
		India	9	6.7
		Australia	14	10.5
		UK	14	10.5
		USA	31	23.3
2.3	Continent	1=Africa	3	2.3
		2=Asia	31	23.3
		3=Europe	37	27.8
		4=Latin America and the Caribbean	8	6.0
		5=North America	39	29.3
		6=Oceania and Australia	15	11.3
2.7	Size HEI	≥ 30,000 students	42	31.6
		≥ 12,000 students	55	41.3
		≥ 5,000 students	17	12.8
		< 5,000 students	14	10.5
		NA	5	3.8

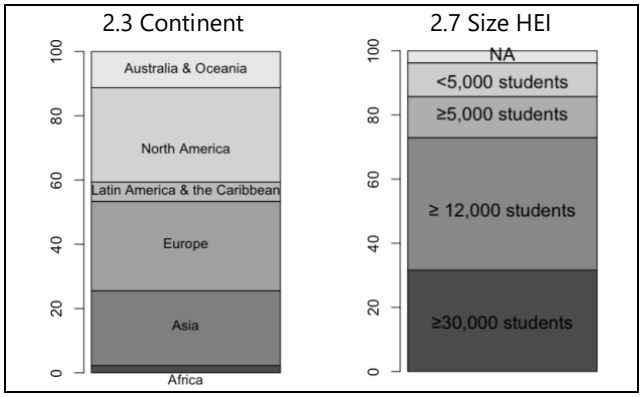

Figure 2 Frequency bar plots (in percent) of category: Basic Data HEI – based on 133 case studies on sustainability curricula implementation processes in higher education institutions around the globe

2.	**BASIC DATA HEI** – Metric variables							
Nr.	**Variable name**	**Min.**	**1st Qu.**	**Median**	**Mean**	**3rd Qu.**	**Max.**	**NA's**
2.4	Number of faculty	56	775.5	1951.5	3116.9	3568.2	39500	21
2.5	Number of management staff	117	1060	1981	3701	3369	27522	60
2.6	Number of students	638	12344	22811	51726	33746	3000000	5

2.4 Variable Category 3: Educational Environment

3.	**EDUCATIONAL ENVIRONMENT** – Categorical variables			
Nr.	**Variable name**	**Value label**	**Frequency**	**Percent**
3.3	Diversity sustainability study programs	weak	23	17.3
		medium	30	22.5
		high	34	25.6
		NA	46	34.6
3.4	Diversity of disciplines	weak	10	7.5
		medium	22	16.5
		high	100	75.2
		NA	1	0.8
3.4.1	Diversity of disciplines - Humanities & social sciences	no	2	1.5
		yes	130	97.7
		NA	1	0.8
3.4.2	Diversity of disciplines - Natural sciences	no	10	7.5
		yes	122	91.7
		NA	1	0.8
3.4.3	Diversity of disciplines - Life sciences	no	16	12.0
		yes	116	87.2
		NA	1	0.8
3.4.4	Diversity of disciplines - Engineering	no	17	12.8
		yes	115	86.4
		NA	1	0.8
3.4.5	Diversity of disciplines - Sustainability sciences	no	88	66.2
		yes	43	32.3
		NA	2	1.5
3.5	Existence of interdisciplinary spaces	lack of/barrier	12	9.0
		differing	3	2.3
		yes/driver	54	40.6
		other	8	6.0
		NA	56	42.1
3.6	Structure & relationship of study programs	lack of	3	2.3
		yes	48	36.1
		other	14	10.5
		NA	68	51.1
3.9	Supportive culture of teaching and learning	weak	6	4.5
		medium	26	19.5
		high	19	14.3
		other	7	5.3
		NA	75	56.4
3.10	Crowded curriculum	yes/barrier	18	13.5
		differing	6	4.5
		no/driver	1	0.8
		other	3	2.2
		NA	105	79

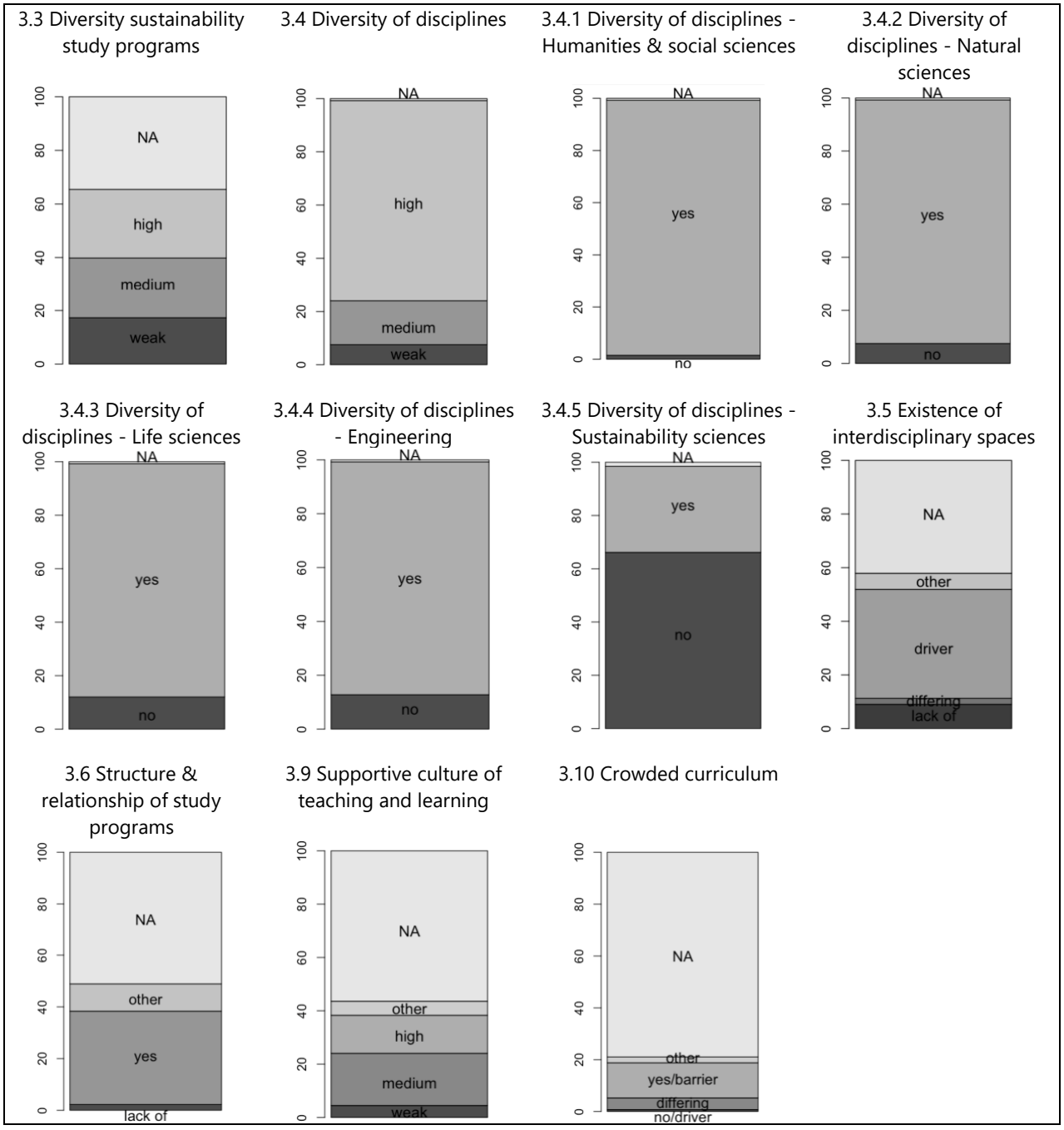

Figure 3 Frequency bar plots (in percent) of category: Educational Environment – based on 133 case studies on sustainability curricula implementation processes in higher education institutions around the globe

3.	**EDUCATIONAL ENVIRONMENT**– Metric variables							
Nr.	**Variable name**	**Min.**	**1st Qu.**	**Median**	**Mean**	**3rd Qu.**	**Max.**	**NA's**
3.1	Number of all programs	13	74	162	206	289	855	30
3.1.1	Number of undergrad programs	0	30	73	90.86	127	437	8
3.1.2	Number of grad programs	0	27	60	80.29	114	307	8
3.1.3	Number of doctoral programs	0	7	31	36.76	51	151	31
3.2.	Number of all sustainability programs	0	2	6	7.955	11	35	44
3.2.1	Number of undergrad sustainability programs	0	0	2	2.673	4	12	26
3.2.2	Number of grad sustainability programs	0	1	2	3.532	5	15	24
3.2.3	Number of doctoral sustainability programs	0	0	0	1.456	2	13	43

2.4 Variable Category 4: Implementation Process

4.	**IMPLEMENTATION PROCESS** – Categorical variables			
Nr.	**Variable name**	**Value label**	**Frequency**	**Percent**
4.3	Institutional level of the sustainability curricula implementation process	institution	78	58.6
		division	11	8.3
		program	7	5.3
		course	13	9.8
		other	23	17.3
		NA	1	0.7
4.4	Integration approach of the sustainability curricula implementation process	existing courses	11	8.3
		existing programs	8	6.0
		minor	1	0.8
		major	6	4.5
		general studies approach	64	48.1
		new department	8	6.0
		other	31	23.3
		NA	4	3.0
4.6	Initiation – Bottom-up/top-down	bottom-up	27	20.3
		top-down	24	18.0
		other	38	28.6
		NA	44	33.1
4.7	Window of opportunity	lack of/barrier	1	0.8
		differing	1	0.8
		yes/driver	60	45.1
		other	3	2.3
		NA	68	51.0
4.7.1	Window of opportunity - Characteristics: Forthcoming accreditation processes	lack of, described as missing	1	0.8
		yes	2	1.5
		NA	130	97.7
4.7.2	Window of opportunity - Characteristics: Change of faculty	lack of, described as missing	1	0.8
		yes	3	2.3
		NA	129	96.9
4.7.3	Window of opportunity - Characteristics: Change of top management	lack of, described as missing	0	0
		yes	13	9.8
		NA	120	90.2
4.7.4	Window of opportunity - Characteristics: State support	lack of, described as missing	1	0.8
		yes	22	16.5
		NA	110	82.7
4.7.5	Window of opportunity - Characteristics: Requirement to restructure HEI (extern)	lack of, described as missing	0	0
		yes	7	5.3
		NA	126	94.7
4.7.6	Window of opportunity - Characteristics: Evaluation/reform of programs (intern)	lack of, described as missing	1	0.8
		yes	9	6.7
		NA	123	92.5
4.7.7	Window of opportunity - Characteristics: Political reforms	lack of, described as missing	0	0
		yes	25	18.8
		NA	108	81.2

4.	**IMPLEMENTATION PROCESS** – Categorical variables *(continued)*			
Nr.	**Variable name**	**Value label**	**Frequency**	**Percent**
4.7.8	Window of opportunity - Characteristics: Other	lack of, described as missing	1	0.8
		yes	27	20.1
		NA	105	79.0
		Topics mentioned were, for instance, rising awareness, loss of momentum, visioning process, ISO14001, change of internal structure, funding, faculty involvement		
4.8	Existence of a coordination unit	lack of/barrier	4	3.0
		medium/differing	17	12.8
		yes/driver	63	47.4
		other	8	6.0
		NA	41	30.8
4.9	Communication strategy	lack of/barrier	8	6.0
		differing	32	24.1
		yes/driver	50	37.6
		other	4	3.0
		NA	39	29.3
4.9.1	Communication strategy - Characteristics: Information campaign	lack of, described as missing	4	3.0
		yes	14	10.5
		NA	115	86.5
4.9.2	Communication strategy - Characteristics: Involvement of diff. stakeholders	lack of, described as missing	1	0.8
		yes	53	39.8
		NA	79	59.4
4.9.3	Communication strategy - Characteristics: Point of contact	lack of, described as missing	1	0.8
		yes	44	33.1
		NA	88	66.1
4.9.4	Communication strategy - Characteristics: Other	lack of, described as missing	4	3.0
		yes	53	39.9
		NA	76	57.1
		Topics mentioned were, for instance, awareness raising activities, internal discourse, (international) conferences, web resource, audit, workshops, guidelines, networking, communities of practice, environmental council, environmental report, course inventory, public showcase of coursework, interlocutors, envisioning and engagement process, limited duration of communication		

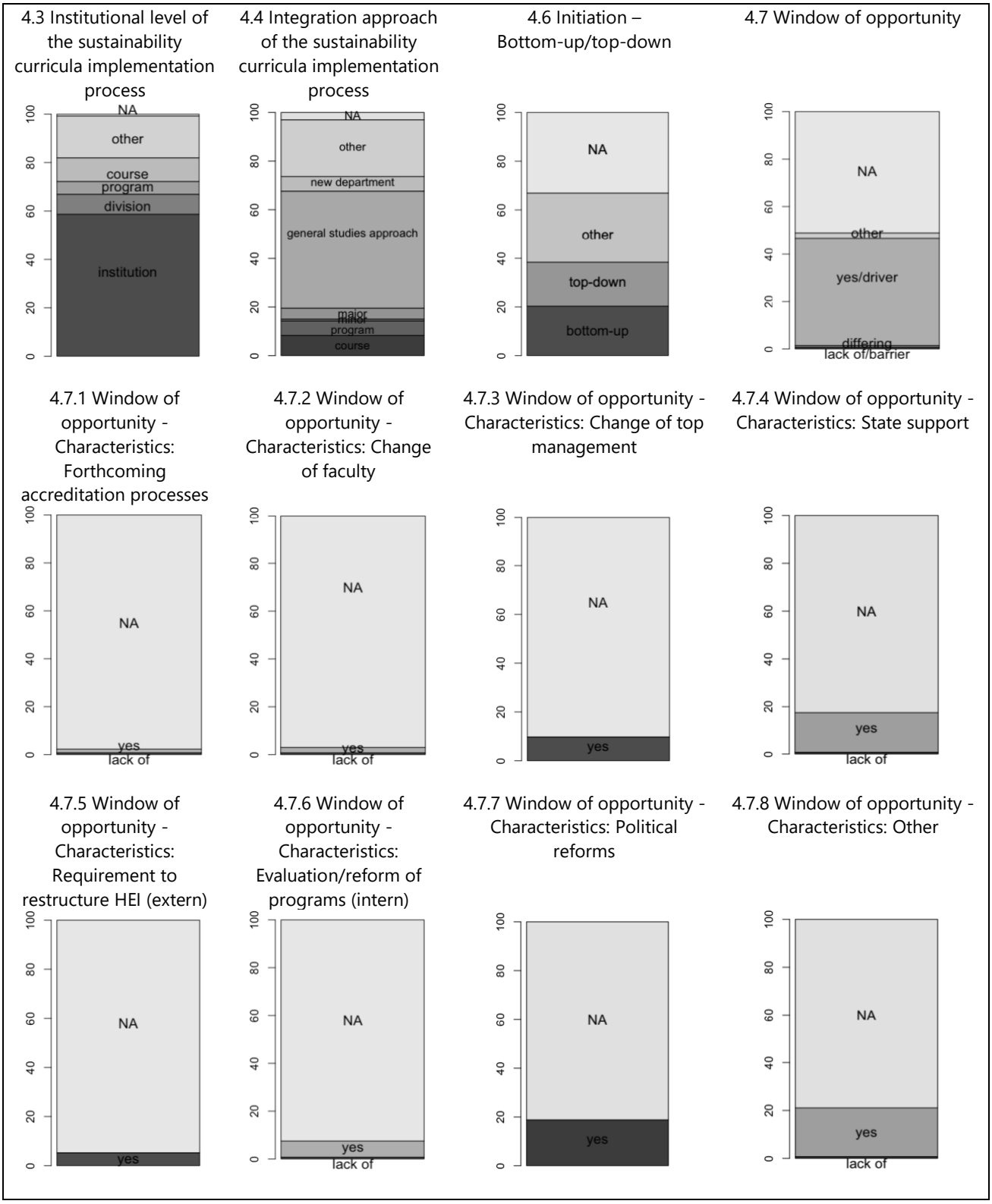

Figure 4 Frequency bar plots (in percent) of category: Implementation process (part A) – based on 133 case studies on sustainability curricula implementation processes in higher education institutions around the globe

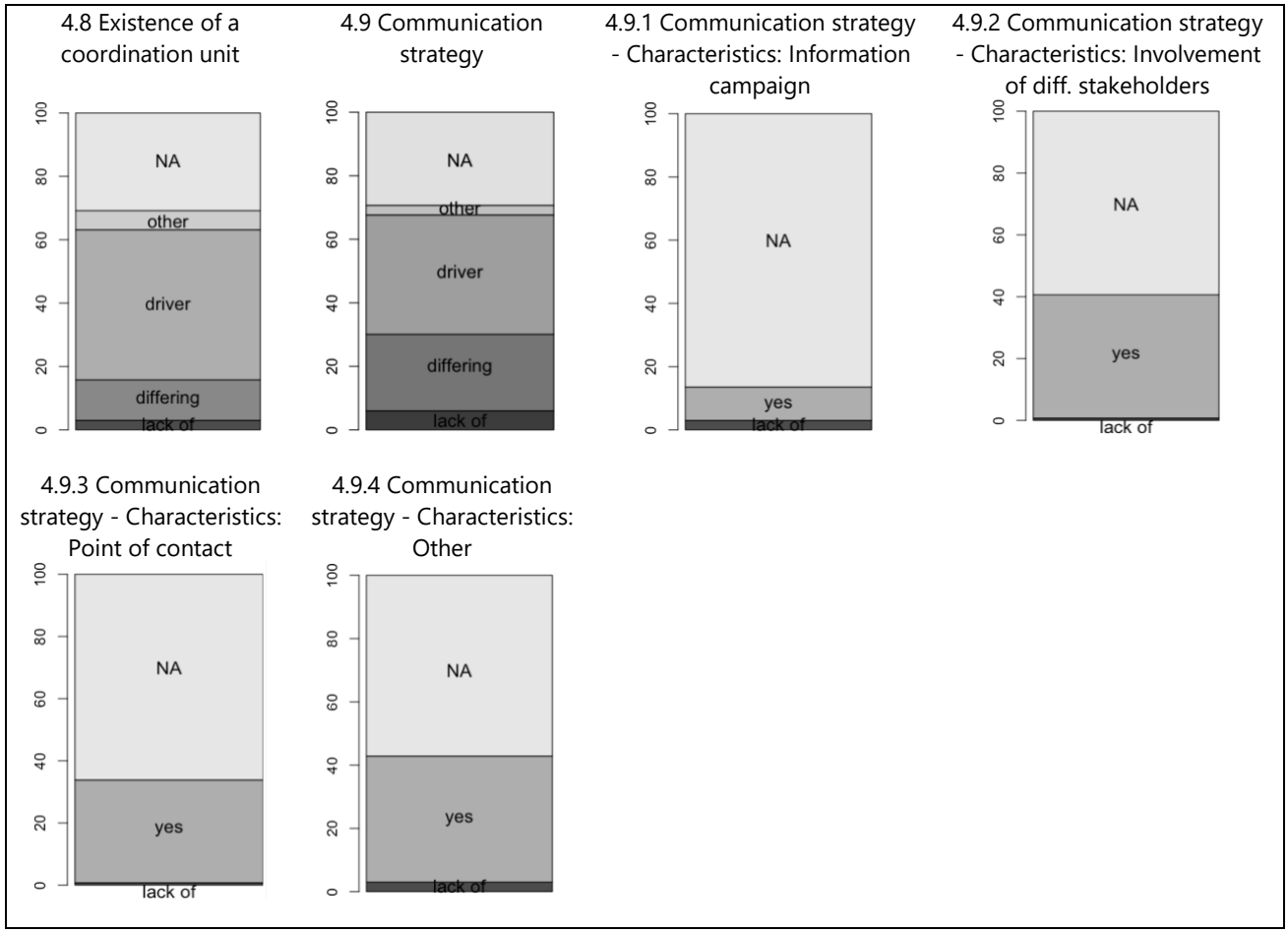

Figure 5 Frequency bar plots (in percent) of category: Implementation process (part B) – based on 133 case studies on sustainability curricula implementation processes in higher education institutions around the globe

4.	**IMPLEMENTATION PROCESS**– Metric variables							
Nr.	**Variable name**	**Min.**	**1st Qu.**	**Median**	**Mean**	**3rd Qu.**	**Max.**	**NA's**
4.1	Period of sustainability curricula implementation process - Start	1910	1992	2000	1998	2008	2017	0
4.2	Period of sustainability curricula implementation process - End	1999	2009	2013	2011	2015	2018	0

2.6 Variable Category 5: Leadership

5.	LEADERSHIP			
Nr.	**Variable name**	**Value label**	**Frequency**	**Percent**
5.1	Strategic planning	lack of/barrier	9	6.8
		medium/differing	20	15.0
		yes/driver	55	41.3
		other	11	8.3
		NA	38	28.6
5.2	Vision & mission	not mentioned	38	28.6
		mentioned online	25	18.8
		online and driver in CM	44	33.1
		other	18	13.5
		NA	8	6.0
5.3	Resources - Budget	lack of/barrier	29	21.8
		differing	15	11.3
		yes/driver	22	16.5
		other	14	10.5
		NA	53	39.9
5.4	Resources - Time	lack of/barrier	34	25.5
		differing	5	3.8
		yes/driver	5	3.8
		other	5	3.8
		NA	84	63.1
5.5	Resources - Other	lack of/barrier	38	28.6
		differing	8	6.0
		yes/driver	12	9.0
		other	5	3.8
		NA	70	52.6
		Topics mentioned were, for instance, personnel or unspecified resources		
5.6	Internal priority setting - Formal/informal	no, lack of formalization	17	12.8
		differing	12	9.0
		yes, formalization	61	45.9
		other	12	9.0
		NA	31	23.3
5.7	Nature of leadership	weak	13	9.8
		differing (inconsistent)	34	25.6
		strong	45	33.8
		other	7	5.2
		NA	34	25.6
5.8	Organizational culture - Competitive or collaborative environment	competitive/barrier	12	9.0
		differing	23	17.3
		collaborative/driver	30	22.6
		other	6	4.5
		NA	62	46.6
5.9	Organizational structure	lack of/barrier	29	21.8
		differing	17	12.8
		sufficient/driver	16	12.0
		other	2	1.5
		NA	69	51.9

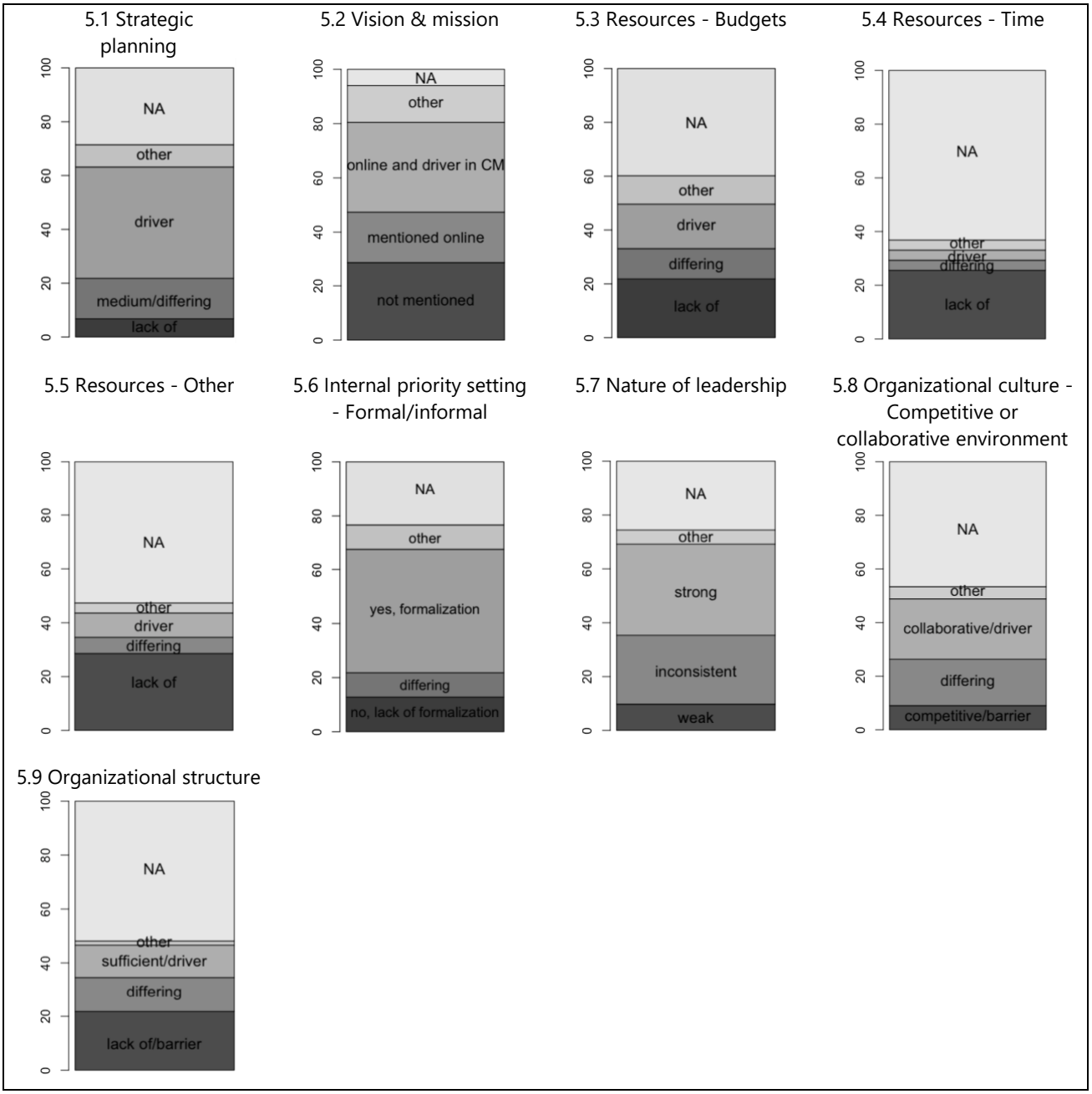

Figure 6 Frequency bar plots (in percent) of category: Leadership – based on 133 case studies on sustainability curricula implementation processes in higher education institutions around the globe

2.7 Variable Category 6: Support mechanisms

6.	SUPPORT MECHANISMS			
Nr.	**Variable name**	**Value label**	**Frequency**	**Percent**
6.1	Professional development opportunities	lack of/barrier	9	6.8
		medium/differing	22	16.5
		yes/driver	35	26.3
		other	25	18.8
		NA	42	31.6
6.1.1	Professional development opportunities - Characteristics: Faculty training	lack of, described as missing	3	2.2
		yes	51	38.4
		NA	79	59.4
6.1.2	Professional development opportunities - Characteristics: Individual coaching	lack of, described as missing	1	0.8
		yes	10	7.5
		NA	122	91.7
6.1.3	Professional development opportunities - Characteristics: Spaces for exchange of expertise (group, network)	lack of, described as missing	0	0
		yes	25	18.8
		NA	108	81.2
6.1.4	Professional development opportunities - Characteristics: Good teaching practices	lack of, described as missing	8	6.0
		yes	27	20.3
		NA	98	73.7
6.1.5	Professional development opportunities - Characteristics: Other	lack of, described as missing	2	1.5
		yes	30	22.6
		NA	101	75.9
6.2	Incentives	lack of/barrier	19	14.3
		medium/differing	17	12.8
		yes/driver	13	9.8
		other	9	6.8
		NA	75	56.3
6.2.1	Incentives - Characteristics: Awards (intern)	lack of, described as missing	3	2.3
		yes	10	7.5
		NA	120	90.2
6.2.2	Incentives - Characteristics: Awards (extern)	lack of, described as missing	0	0
		yes	14	10.5
		NA	119	89.5
6.2.3	Incentives - Characteristics: Financial	lack of, described as missing	4	3.0
		yes	14	10.5
		NA	115	86.5
6.2.4	Incentives - Characteristics: Time	lack of, described as missing	4	3.0
		yes	3	2.3
		NA	126	94.7
6.2.5	Incentives – Characteristics: Promotion	lack of, described as missing	9	6.8
		yes	2	1.5
		NA	122	91.7
6.2.6	Incentives - Characteristics: Other	lack of, described as missing	3	2.3
		yes	8	6.0
		NA	122	91.7

6.	**SUPPORT MECHANISMS *(continued)***			
Nr.	**Variable name**	**Value label**	**Frequency**	**Percent**
6.3	Quality assurance mechanisms	lack of	9	6.8
		differing	36	27.1
		established	14	10.5
		research method	20	15.0
		other	13	9.8
		NA	41	30.8

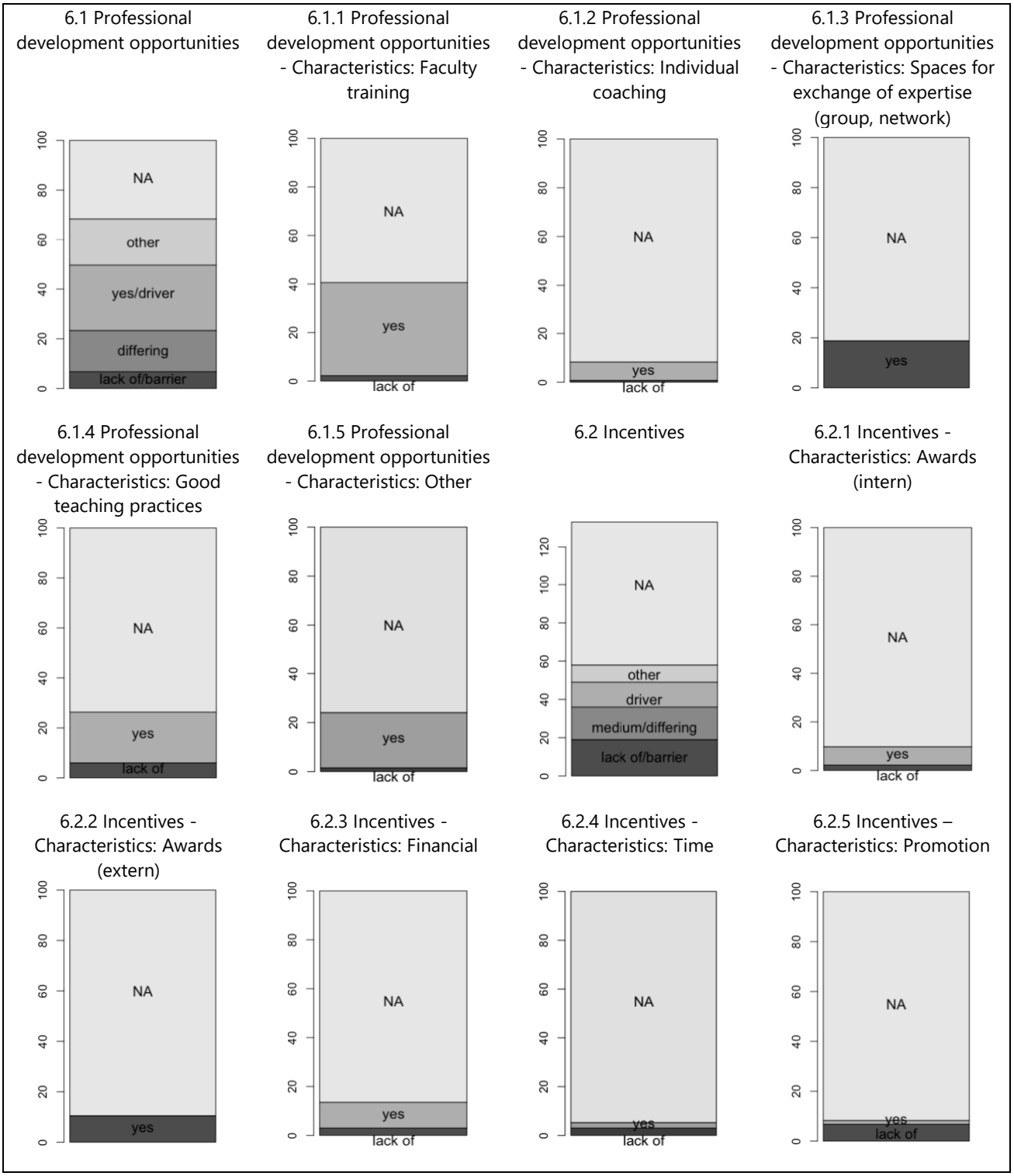

Figure 7 Frequency bar plots (in percent) of category: Support mechanisms (part A) – based on 133 case studies on sustainability curricula implementation processes in higher education institutions around the globe

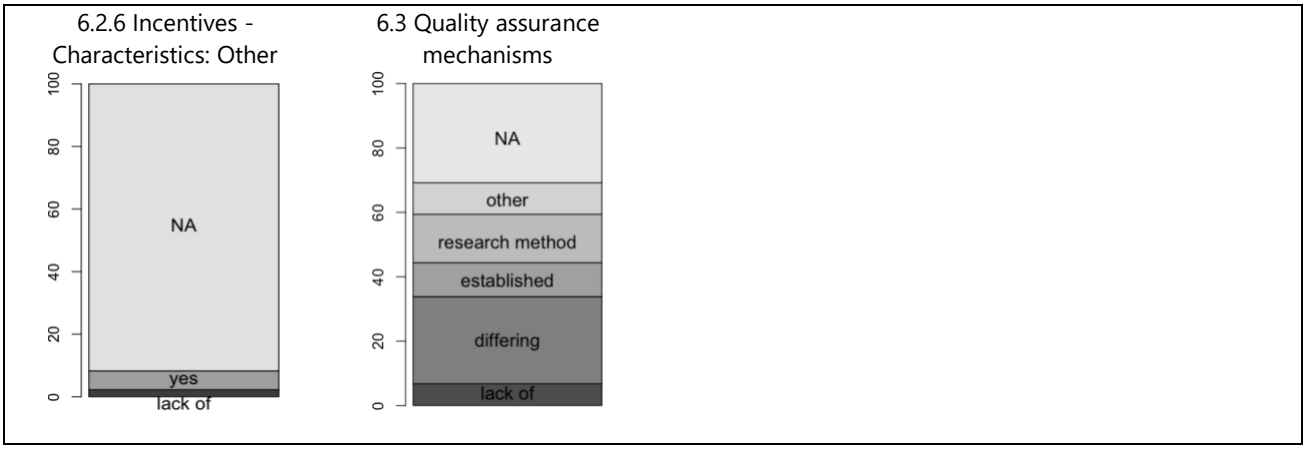

Figure 8 Frequency bar plots (in percent) of category: Support mechanisms (part B) – based on 133 case studies on sustainability curricula implementation processes in higher education institutions around the globe

2.8 Variable Category 7: Internal Stakeholders

7.	INTERNAL STAKEHOLDERS			
Nr.	**Variable name**	**Value label**	**Frequency**	**Percent**
7.1	Involvement - Faculty	lack of	0	0
		formal	49	36.8
		informal	15	11.3
		other	37	27.8
		NA	32	24.1
7.2	Involvement - Students	lack of	0	0
		formal	48	36.1
		informal	9	6.8
		other	18	13.5
		NA	58	43.6
7.3	Involvement - Management	lack of	0	0
		formal	37	27.8
		informal	5	3.8
		other	10	7.5
		NA	81	60.9
7.4	Involvement - External stakeholders	lack of	0	0
		formal	33	24.8
		informal	6	4.5
		other	31	23.3
		NA	63	47.4
7.5	Support - Management	lack of/barrier	7	5.2
		medium/differing	15	11.3
		high/driver	48	36.1
		other	15	11.3
		NA	48	36.1
7.6	Support - Administration	lack of/barrier	7	5.3
		medium/differing	13	9.8
		high/driver	20	15
		other	8	6
		NA	85	63.9
7.7	Support - Faculty	lack of/barrier	2	1.5
		medium/differing	58	43.6
		high/driver	27	20.3
		other	11	8.3
		NA	35	26.3
7.8	Support - Generic	lack of/barrier	2	1.5
		differing	8	6
		high/driver	14	10.5
		other	7	5
		NA	102	77
7.9	Interdisciplinary competence - Faculty	lack of/barrier	39	29.3
		medium/differing	19	14.3
		high/driver	17	12.8
		other	10	7.5
		NA	48	36.1

7.	INTERNAL STAKEHOLDERS *(continued)*			
Nr.	**Variable name**	**Value label**	**Frequency**	**Percent**
7.10	Perception of sustainable development - Faculty	negative/barrier	1	0.8
		medium/differing	39	29.3
		positive/driver	14	10.5
		other	4	3.0
		NA	75	56.4
7.11	Perception of change - Faculty	negative/barrier	5	3.8
		differing	13	9.8
		positive/driver	3	2.2
		other	5	3.8
		NA	107	80.4
7.12	Dissatisfaction with the institutions current program - Faculty	no dissatisfaction	0	0
		differing	4	3.0
		high	2	1.5
		other	0	0
		NA	127	95.5
7.13	Attitude towards innovative T&L approaches - Faculty	negative/barrier	5	3.8
		medium/differing	16	12.0
		positive/driver	20	15.0
		other	6	4.5
		NA	86	64.7
7.14	Perceived links to existing curriculum - Faculty	negative/barrier	4	3.0
		medium/differing	28	21.0
		positive/driver	3	2.3
		other	13	9.7
		NA	85	64.0
7.15	Acceptance - Students	no acceptance/barrier	0	0
		differing	26	19.6
		high/driver	42	31.6
		other	9	6.8
		NA	56	42
7.16	Engagement - Students	lack of	0	0
		yes/curriculum change	17	12.8
		yes/no curriculum change	18	13.5
		other	19	14.3
		NA	79	59.4
7.17	Sustainability champions	lack of/barrier	2	1.5
		medium	6	4.5
		yes/driver	51	38.3
		other	3	2.3
		NA	71	53.4

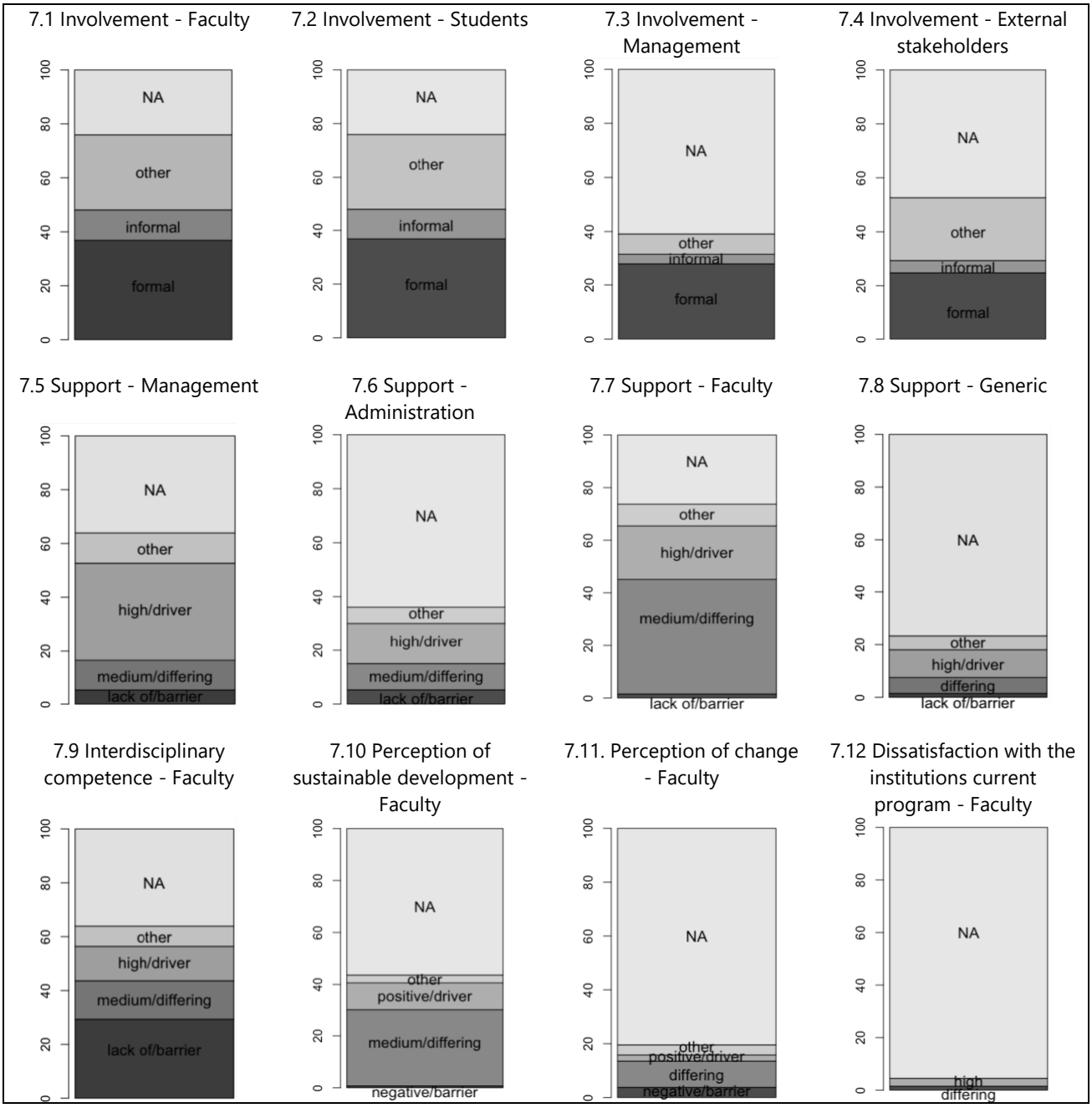

Figure 9 Frequency bar plots (in percent) of category: Internal stakeholders (part A) – based on 133 case studies on sustainability curricula implementation processes in higher education institutions around the globe

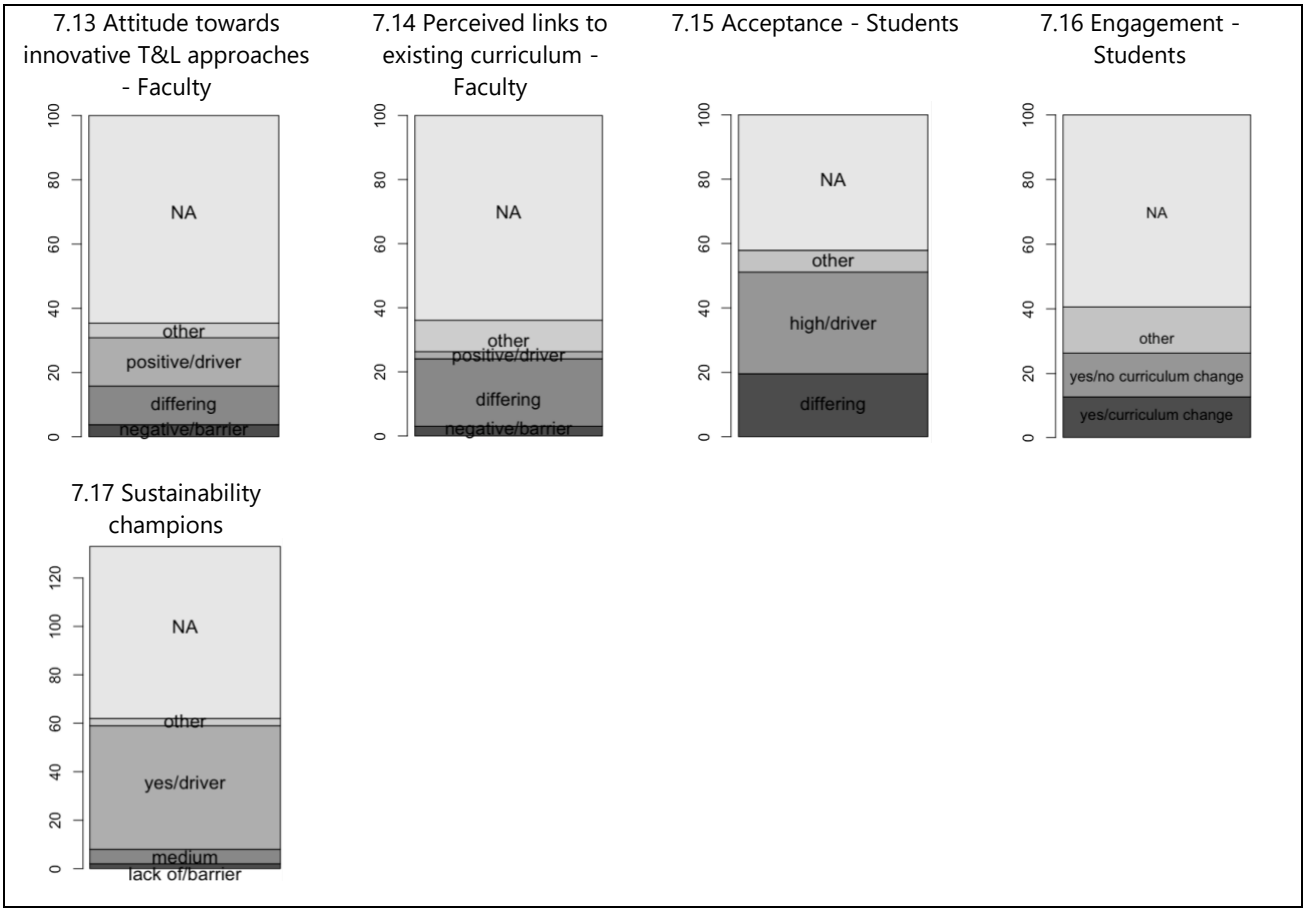

Figure 10 Frequency bar plots (in percent) of category: Internal stakeholders (part B) – based on 133 case studies on sustainability curricula implementation processes in higher education institutions around the globe

2.9 Variable Category 8: Sociocultural Context

8.	SOCIOCULTURAL CONTEXT			
Nr.	**Variable name**	**Value label**	**Frequency**	**Percent**
8.1	Accrediting agencies	none/barrier	1	0.8
		medium	4	3.0
		yes/driver	8	6.0
		other	4	3.0
		NA	116	87.2
8.2	Professional associations	none/barrier	1	0.8
		medium	3	2.2
		yes/driver	13	9.8
		other	3	2.2
		NA	113	85.0
8.3	Market forces	none/barrier	1	0.8
		medium	11	8.3
		yes/driver	30	22.5
		other	8	6.0
		NA	83	62.4
8.4	Media	none/barrier	0	0
		medium	2	1.5
		yes/driver	2	1.5
		other	0	0
		NA	129	97.0
8.5	Public discourse	none/barrier	2	1.5
		medium	5	3.7
		yes/driver	27	20.3
		other	1	0.8
		NA	98	73.7
8.6	Government - State & federal laws	none/barrier	0	0
		medium	12	9.0
		yes/driver	53	39.9
		other	4	3.0
		NA	64	48.1
8.7	Context – Other (transformed into binary variable)	no	33	24.8
		yes	100	75.2
		Topics mentioned were, for instance, NGOs, UN activities (mostly ESD UN decade), Regional center of expertise RCE), networks, (international) cooperation with other HEIs, local activities, alumni		

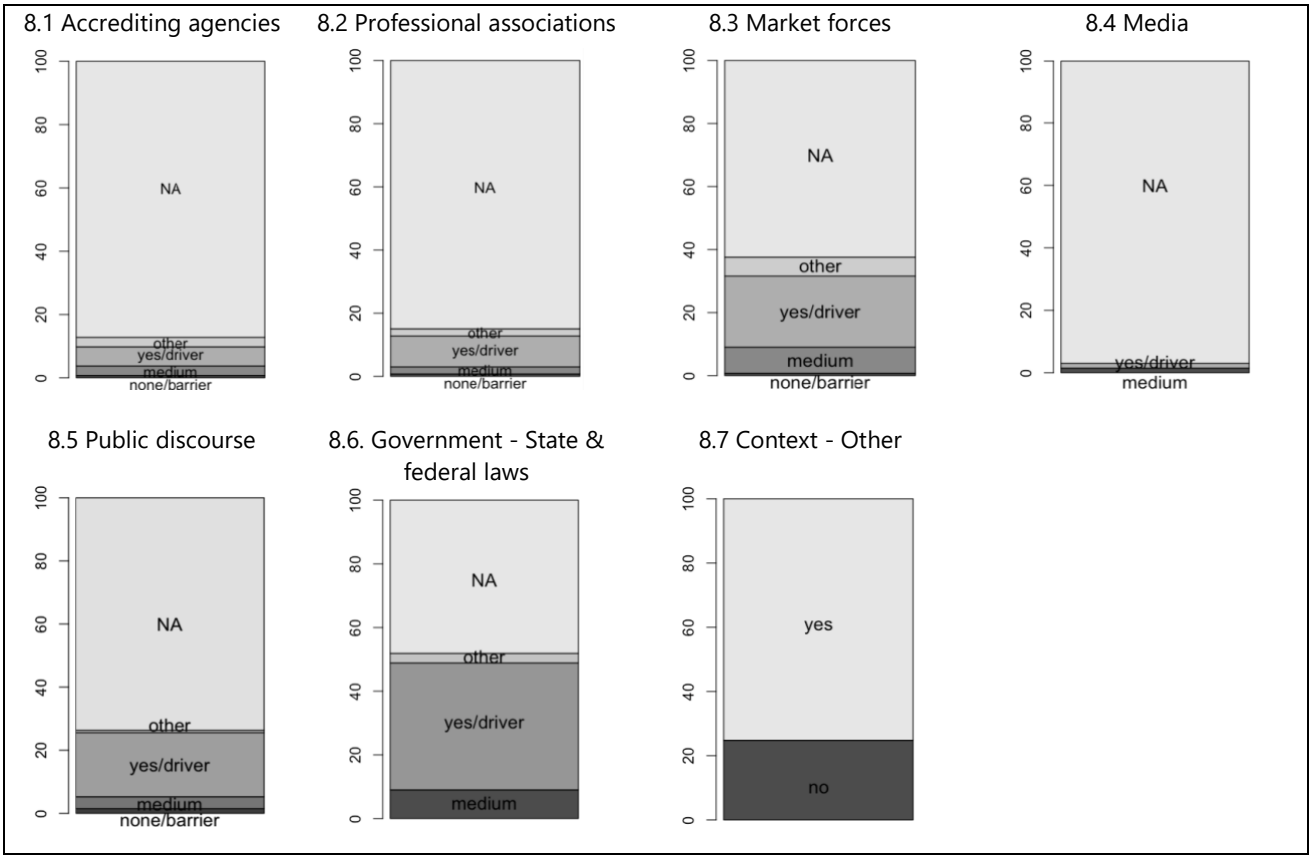

Figure 11 Frequency bar plots (in percent) of category: Sociocultural Context – based on 133 case studies on sustainability curricula implementation processes in higher education institutions around the globe

2.10 Variable Category 9: Level of Sustainability Curricula Implementation

9.	LEVEL OF SUSTAINABILITY CURRICULA IMPLEMENTATION			
Nr.	**Variable name**	**Value label**	**Frequency**	**Percent**
9.1	Grade of activity	recently started	2	1.5
		established	17	12.8
		long tradition	106	79.7
		NA	8	6.0
9.2	Sustainability curricula implementation	no change	1	0.8
		bolt-on	36	27.0
		build-in	75	56.4
		redesign	21	15.8
9.3	Areas of activity - Research	no activities	1	0.8
		active	27	20.3
		significant	42	31.6
		core focus	14	10.5
		NA	49	36.8
9.4	Areas of activity - Campus operations	no activities	6	4.5
		active	15	11.3
		significant	24	18.0
		core focus	29	21.8
		NA	59	44.4
9.5	Areas of activity - Outreach	no activities	2	1.5
		active	21	15.8
		significant	22	16.5
		core focus	10	7.5
		NA	78	58.7
9.6	Areas of activity - Synergies	no synergies	2	1.5
		medium	40	30.1
		pushed	15	11.3
		NA	76	57.1
9.7	Origin of sustainability activities	research	5	3.8
		teaching & learning	20	15.0
		campus operations	10	7.5
		outreach	0	0
		other	11	8.3
		NA	87	65.4

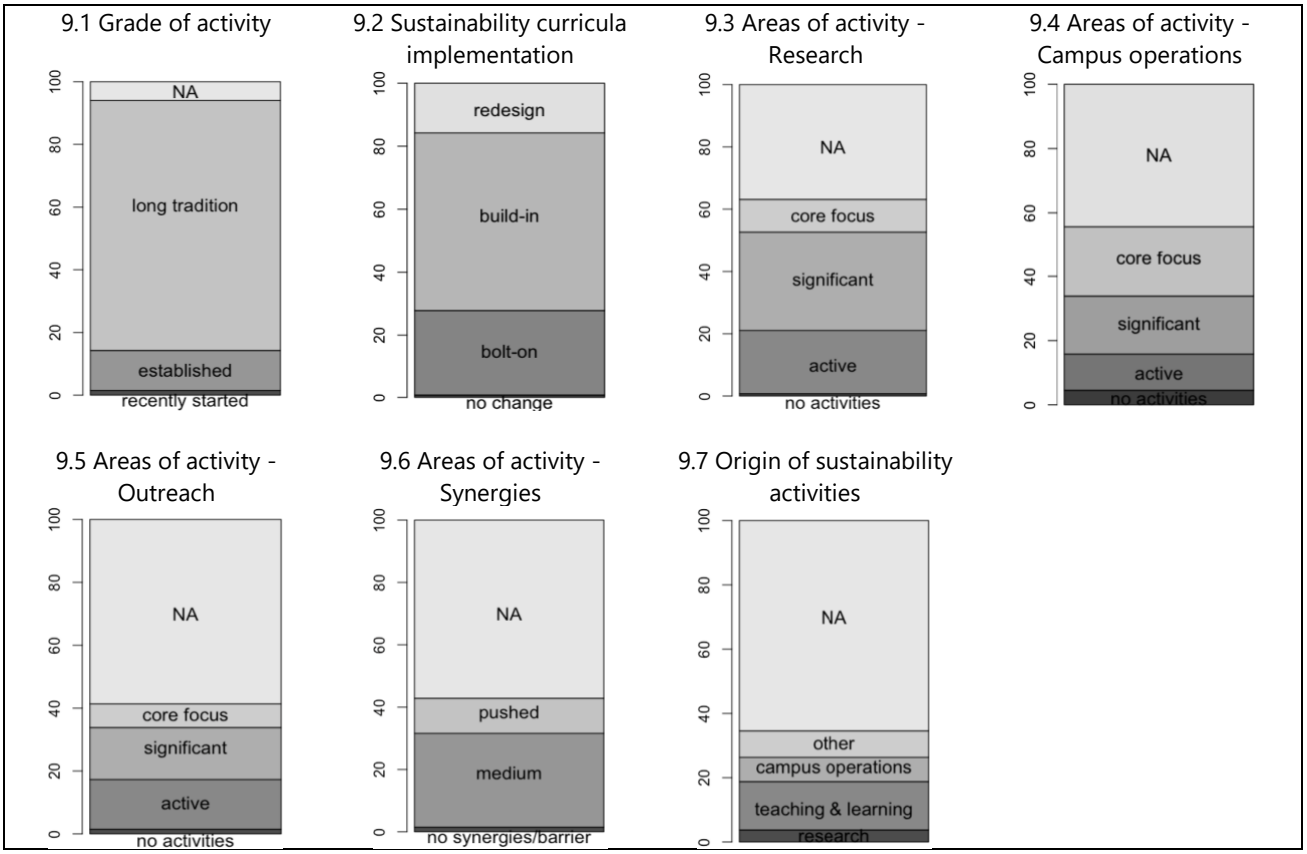

Figure 12 Frequency bar plots (in percent) of category: Level of Sustainability Curricula Implementation – based on 133 case studies on sustainability curricula implementation processes in higher education institutions around the globe