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Drivers and Barriers of Implementing Sustainability Curricula in Higher Education - Assumptions and Evidence

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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

1. Introduction

1.1 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) (United Nations [UN], 2020). 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" (World Commission on Environment and Development [WCED], 1987, chapter 2, paragraph 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, Rieckmann, & Barth, 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 1). 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.

1.2 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 1), 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 1. 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 (N. Evans & Henrichsen, 2008). Numerous stakeholders with different interests, values, and attitudes are required for curriculum changes (Blanco-Portela, Benayas, Pertierra, & Lozano, 2017; Cortese, 2003), which makes implementing sustainability curricula challenging (Thomas, 2016).

Building upon broader curriculum change research (Barnett, Parry, & Coate, 2001; Geschwind, 2019; Keesing-Styles, Nash, & Ayres, 2014; Lattuca & Stark, 2009), a number of studies have been conducted on implementing sustainability curricula in HEIs (Barth, Michelsen, Rieckmann, & Thomas, 2016; Weiss & Barth, 2019). In particular supporting and hindering factors have been studied through literature reviews (Velazquez, Munguia, Platt, & Taddei, 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, Rodhe, & Huisingh, 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, Jones, Karvonen, Millard, & Wendler, 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; Vargas, Lawthom, Prowse, Randles, & Tzoulas, 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, Yarime, McCormick, Doll, & Kraines, 2014; Wiek, Xiong, Brundiers, & van der Leeuw, 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, Bormann, Kummer, Niedlich, & Rieckmann, 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, Cetinkaya, & Ustun, 2016). Faculty's perception of sustainability, links to their discipline, resistance to change, and take on academic freedom are important influencing factors (Cotton, Bailey, Warren, & Bissell, 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, Henriksen, & Spengler, 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, Dieleman, & Turpin-Marion, 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.

2. 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 cases" (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 2018. 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 appendix Table B1 for a full list of the sample). Information from the respective websites of the HEIs supplemented the data set. 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 1): 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, 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 and 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 A1).

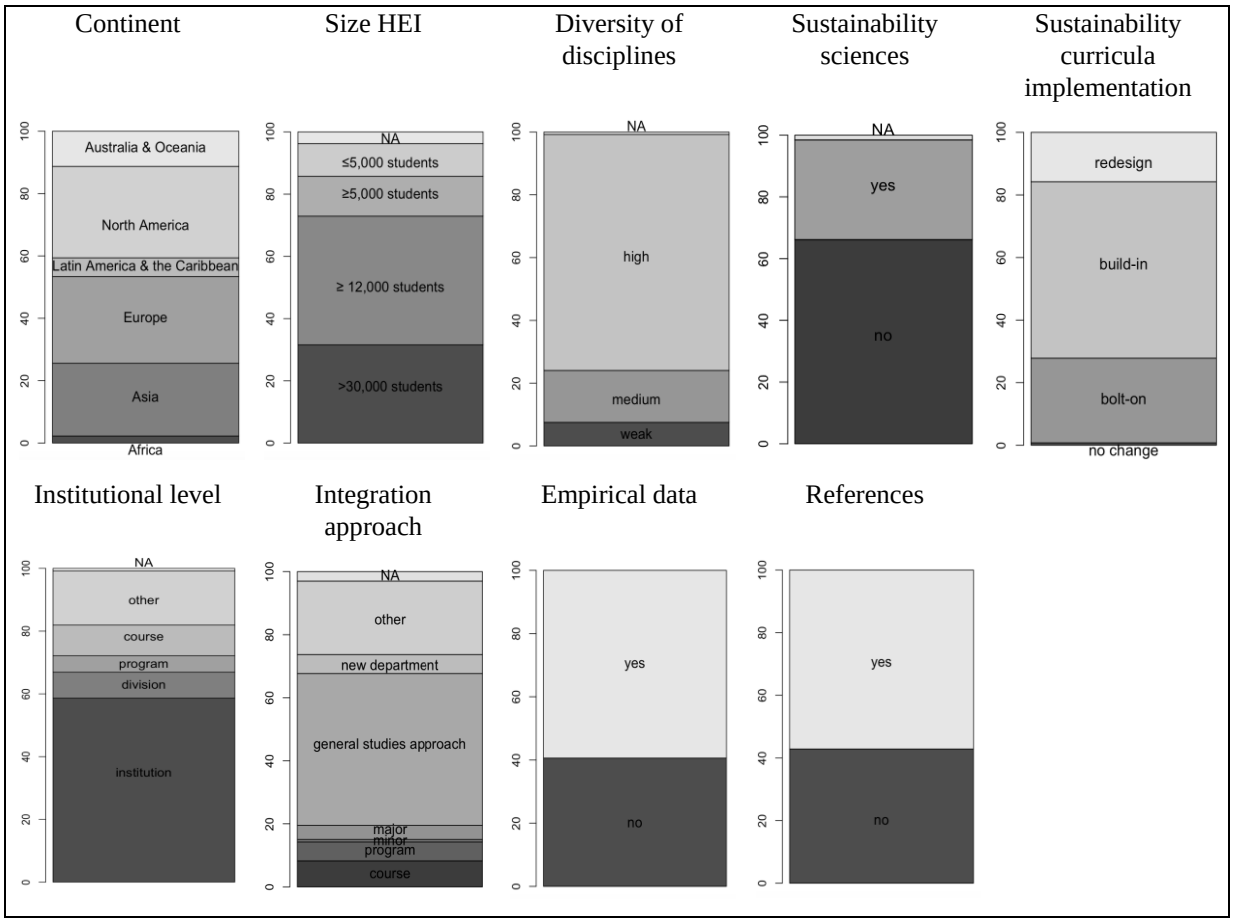


Figure 1. Sample description

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

3. Findings

3.1 Most common Drivers and Barriers of the Implementation

The most common drivers and barriers are listed in Figure 2, 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 2. Most common drivers and barriers for implementing sustainability curricula at HEIs

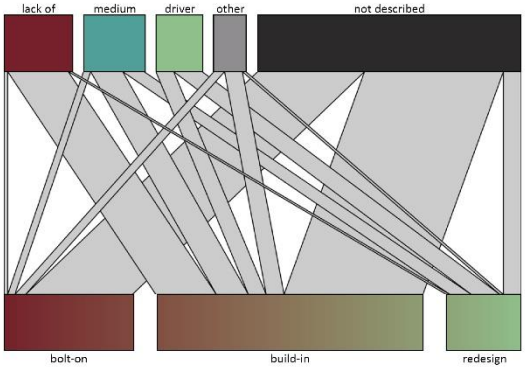
Note. N=133 case studies; values indicate frequency of cases identifying driver/barrier.

3.2 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 3).

Incentives

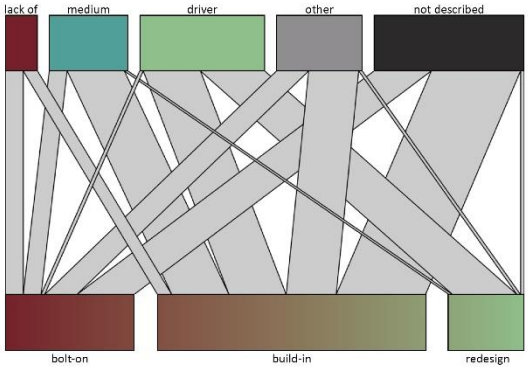


Level of sustainability curricula implementation

	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 3. Linkages between support and sustainability curricula implementation in HEIs

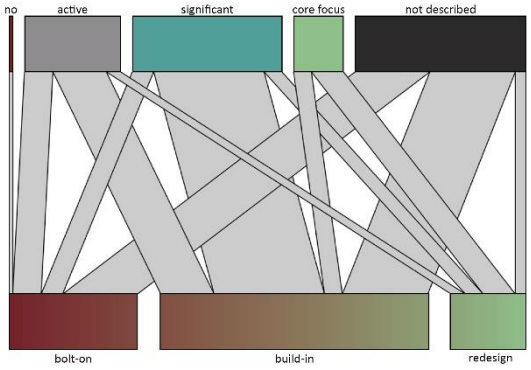
Note. N=132 case studies; calculations are based on Pearson's Chi-squared test with simulated p-value (based on 2000 replicates); the values in each cell depict the count, the expected values, and standardized residuals; *significant at +/- 1.96.

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 4).

Integration with sustainability research

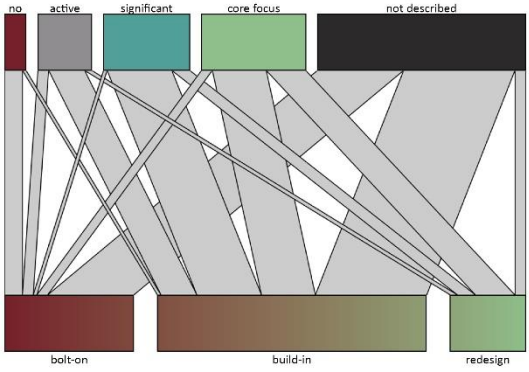


Level of sustainability curricula implementation

	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

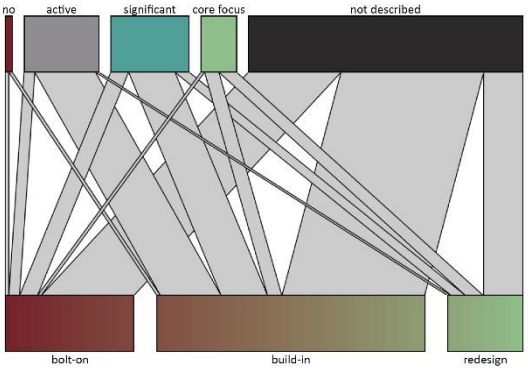


Level of sustainability curricula implementation

	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

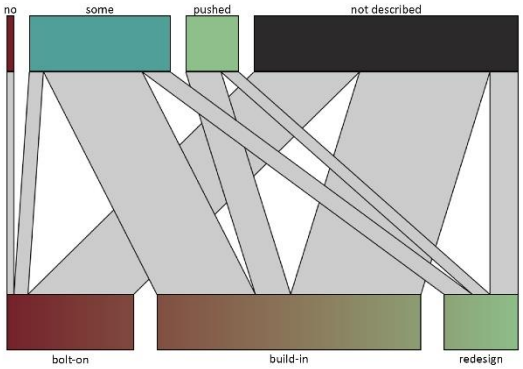


Level of sustainability curricula implementation

	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

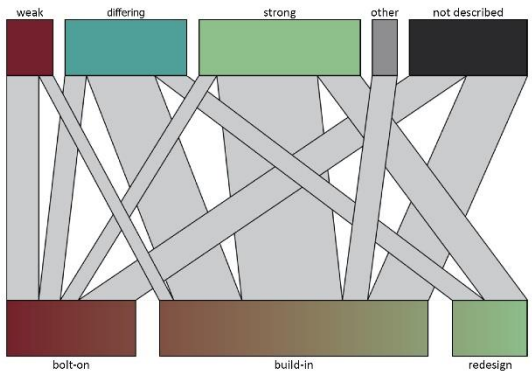
Figure 4. Linkages between the integration of sustainability in research, campus operations, outreach, plus synergies, and sustainability curricula implementation in HEIs

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).



	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. Linkage between leadership and sustainability curricula implementation in HEIs

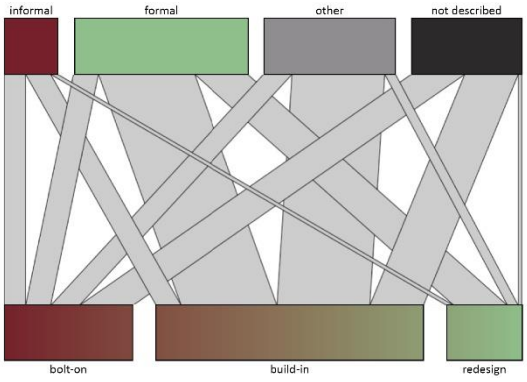
Note. N=132 case studies; calculations are based on Pearson's Chi-squared test with simulated p-value (based on 2000 replicates); the values in each cell depict the count, the expected values, and standardized residuals; *significant at +/- 1.96.

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 6). 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.

Involvement of faculty

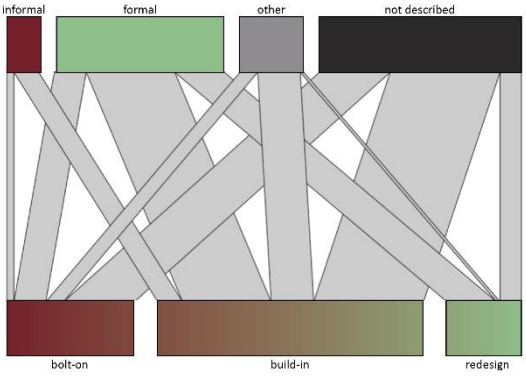


Level of sustainability curricula implementation

	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

Involvement of students



Level of sustainability curricula implementation

	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

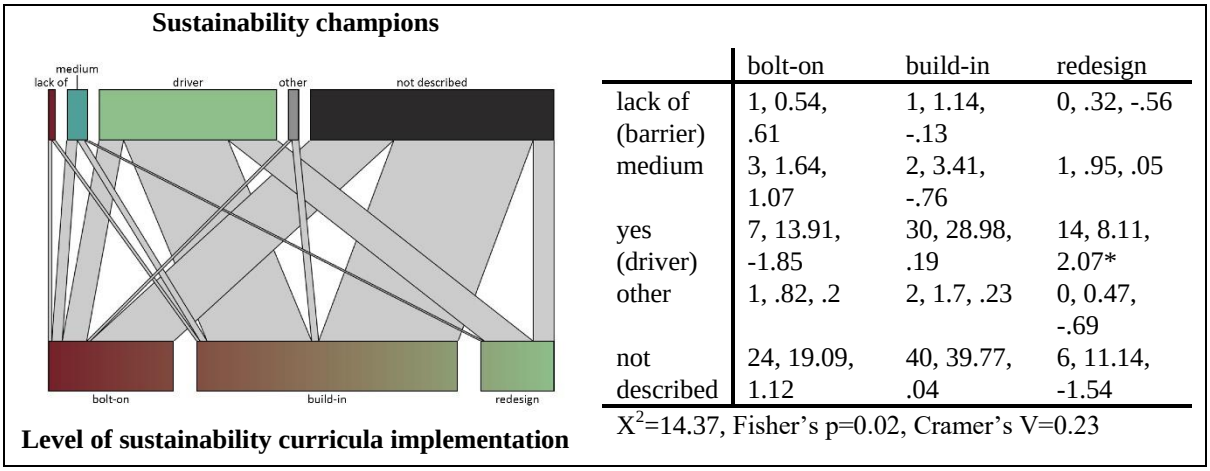
Figure 6. Linkage between involvement of internal stakeholders (faculty, students) and sustainability curricula implementation in HEIs

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 7). 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

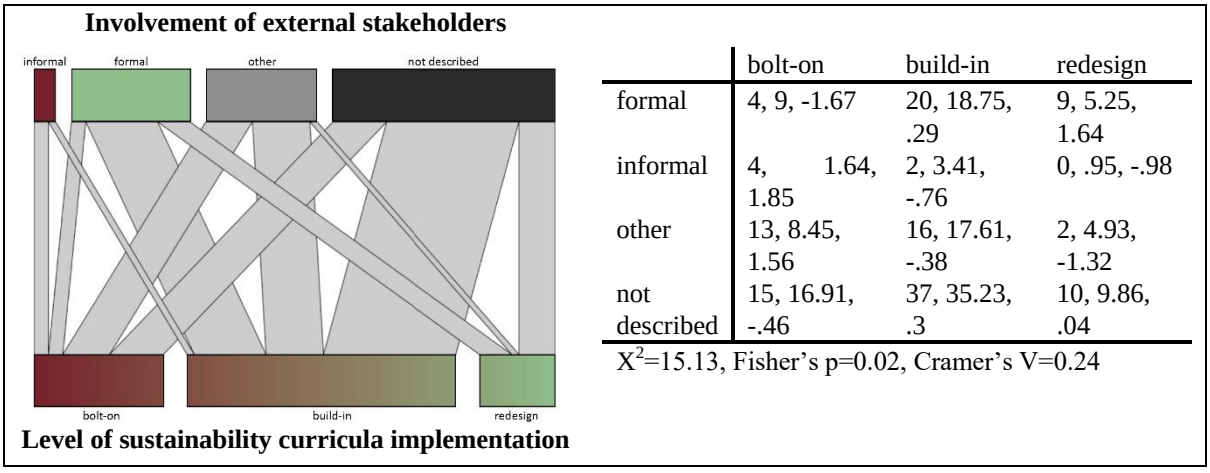
X^2=14.37, Fisher's p=0.02, Cramer's V=0.23

Figure 7. 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 8). 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 8. 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.

4. Discussion

4.1 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, Horan, Moles, & O'Regan, 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, Grahl, & Spira, 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.

4.2 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, Lundqvist, Svanström, & Arehag, 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. 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 framework 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, Lozano, & Alonso-Almeida, 2015; Madeira, Carravilla, Oliveira, & Costa, 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.

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Appendix

Appendix A

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

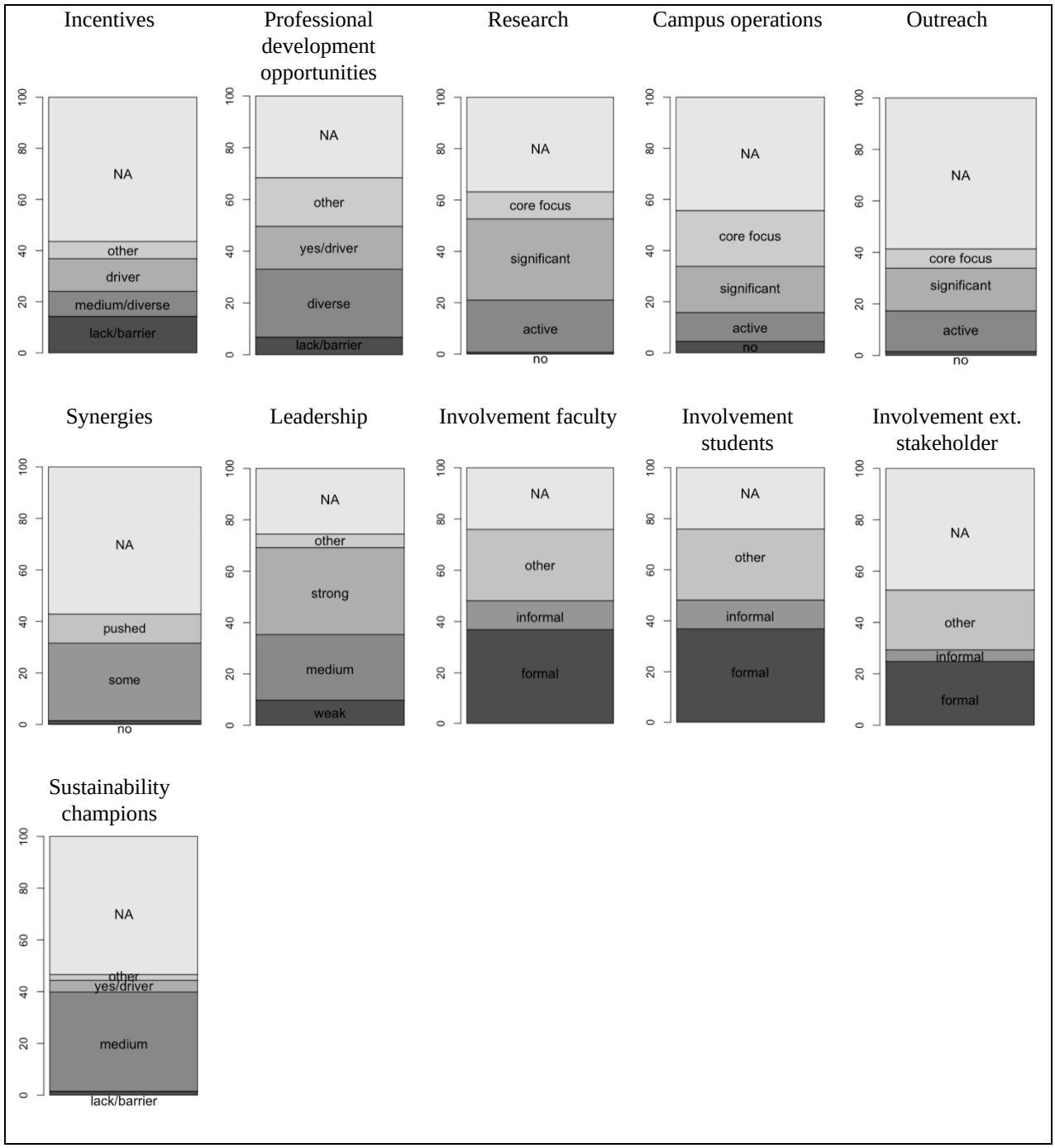

Figure A1. Frequency plots of central variables for the sustainability curricula implementation in higher education institutions. The y-axis shows count in percent (N=132 case studies)

Appendix B

List of case studies that went into the analysis (N = 133)

A full list with all publication is openly available here: Weiss & Barth, 2020b

Table B1. List of case studies that went into the analysis (N = 133)

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)
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

Continent	Country	Name of the Higher Education Institution
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
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

Continent	Country	Name of the Higher Education Institution
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
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