

Linking Teaching and Learning Formats with Students' Development of Key Sustainability Competencies

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Abstract

Educators around the world have put into practice innovative curricula and courses to develop key competencies in sustainability in the next generation of change agents. However, more empirical evidence is needed about the characteristics of these initiatives, which best develop the key competencies, in what contexts, and in what ways. The Educating Future Change Agents project provides some of this evidence through qualitative comparative case studies on courses and curricula at two pioneering universities in Germany and the U.S. These empirical studies are complemented by conceptual and methodological research on the key competencies and their assessment. The purpose of this presentation is to go beyond mere description of a project. Rather I will present a synthesis and integrated results of our diverse studies and ultimately distill the key insights which will support the research and/or practice of faculty, students, staff, university administrators and policy-makers.

This research utilized a range of methods from class observations to focus groups to rigorously seek to empirically link specific teaching and learning formats (and curricular elements) with student development of key competencies. Herein I will present the results from the work of our five PhDs whose topics include teacher education, project-based learning courses, entrepreneurship, comparing curriculums, and a case survey of curriculum implementation globally. The team has been working diligently from the get go to synthesize this extensive body of work. Key moments of learning were identified and through rich data sets linked back to the specific characteristics of the course and curriculum which fostered those moments. The scale and comprehensiveness of this project has provided the unique opportunity for extracting the critically needed generalizable insights.

Introduction

The Educating Future Change Agents (EFCA) project sought to fill a critical research gap by producing both detailed and general insights on how higher education can educate future change agents in key sustainability competencies.

The project was structured into three phases (Fig. X). In Phase I, the team initiated dialogues with stakeholders which validated the use of key competencies in sustainability (Wiek, Withycombe, and Redman 2011; Wiek et al. 2016). These then served as the main reference point of the project. The core part of the project was divided into five separate studies (Phase II). Insights from across the cases were triangulated in a last phase (Phase III).

All qualitative case studies were conducted on educational offerings at Leuphana University of Lüneburg, Germany and Arizona State University, USA. Both universities have fully developed degree programs in sustainability (Bachelor, Master, PhD) and are known for their innovative teaching and learning approaches, including transdisciplinary, problem-based, project-based, and solution-oriented pedagogies (Lang and Wiek 2013; Wiek and Kay 2015; Wiek et al. 2014; 2013). Both have large faculties devoted to sustainability research, teaching, and practice. This has resulted in a broad range of courses and programs which enabled the matching within each study for comparative purposes across the two universities. The close relationship between the two universities enabled the formation of a single project team which moved between locations to conduct the research.

The project was intended not just to add more cases studies that lack comparability (Barth and Thomas 2012), but instead to provide empirical evidence of the characteristics of courses, curriculum, and institutions that led to students' development of key competencies in sustainability. The selected case studies cover pioneering sustainability education offerings to assure the results would be relevant and inspirational for other institutions with ambitions in sustainability education. The team designed the studies in a complementary way that would allow for cross-case comparison. A common empirical framework allowed for generating empirical evidence that could be synthesized and generalized. Below, these three design elements are presented in more detail.

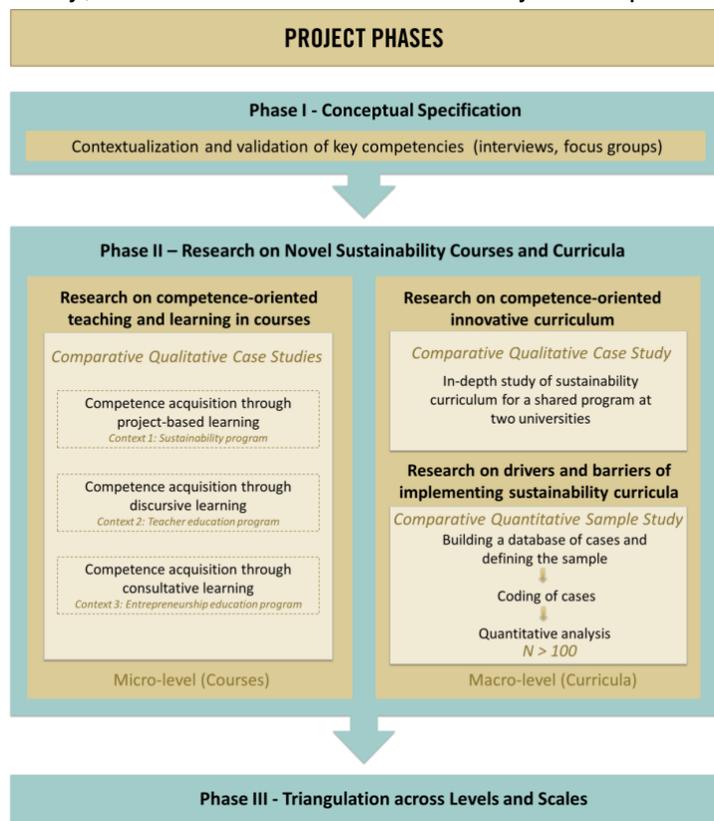


Figure X: Project structure of the Educating Future Change Agents Project

Sample of Pioneering Sustainability Education Offerings

This project captures pioneering offerings from the broad array of sustainability programs currently offered at universities around the globe. Three dominant types of sustainability education efforts in higher education are to educate sustainability professionals, teachers, and managers (Redman, Wiek, and Barth 2020a). Therefore, we conducted three course-level case studies on innovative offerings in these three areas – namely, educating sustainability students in project-based courses, including in international settings; educating aspiring K-12 teachers in how to convey key competencies in sustainability; and educating (business) students in transformational sustainability entrepreneurship (Tab. 1).

Table 1. Key Characteristics of the Courses Selected

	Educating Sustainability Professionals			Educating K-12 Teachers		Educating Entrepreneurs	
	Course 1	Course 2	Course 3	Course 1	Course 2	Course 1	Course 2
University	ASU + LUL	ETH Zurich	UPC Barcelona	ASU	LUL	ASU	LUL
Degree Program	Master's in Global Sustainability Science	Any Masters in Department of Environmental Systems Science	Master's Degree in Sustainability Science and Technology	Primary Education	Primary Education	Various	Various
Level	Graduate	Graduate	Graduate	Undergraduate	Undergraduate	Graduate	Undergraduate
Start	2015			2012	2011	2016	
Course Installment Studied	Fall 2016 – Fall 2017	Summer 2018	Summer 2018	Fall 2017, 2018	Summer 2018	Fall 2016-Fall 2019	
Course Duration	3 semesters	1 semester	1 semester	1 semester	1 semester	1 semester	
Course Status	Mandatory	Elective	Mandatory	Mandatory	Mandatory	Elective	Elective

Average # of students	12	19	15	~120	~80	10-30	
Average # of instructors	4	4	2	5 instructors (seminars)	1 lecturer 3 instructors (seminars) 3 tutors	2	
Exemplary topics / issues addressed	Food economy	Waste management	Energy, Food	Poverty Food Water Energy Production Disposal etc.	ESD theory & practice Mobility Nutrition Use of space	Sustainable business models, practices, and support services	
Primary Learning Objectives				Systems, Futures, Values and Strategic Content knowledge (CK)	Systems, Futures, Values and Strategic Pedagogical Content Knowledge	Transformational - Being able to articulate and justify sustainable business models, practices, and support services	
Teaching - Learning Approach	Solution-oriented learning, project based	Team learning, project based	Service learning, project based	Discursive learning	Discursive learning	Classroom-based Experiential learning	

Teaching - Learning Setting	Real-world and classroom	Real-world and classroom	Real-world and classroom	Classroom and Online	Classroom and Online	Classroom	
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The fourth case study focused on the curriculum level, analyzing the pioneering and innovative master programs in sustainability at Leuphana University of Lüneburg and Arizona State University.

Complementary Studies and Cross-Case Comparison

The project includes four case studies that explore a “bounded system” and offer opportunities to study the manifold factors that produced the unique character of the case (Stake 2008; Creswell 2009). As a preferable strategy to answer ‘how’ and ‘why’ questions, in-depth case studies allow contextual factors, and thus the singularity of a case, to be taken into account (Yin 2003). Multiple case studies and cross-case comparisons are considered viable options to overcome limitations of single case studies (West and Oldfather 1995).

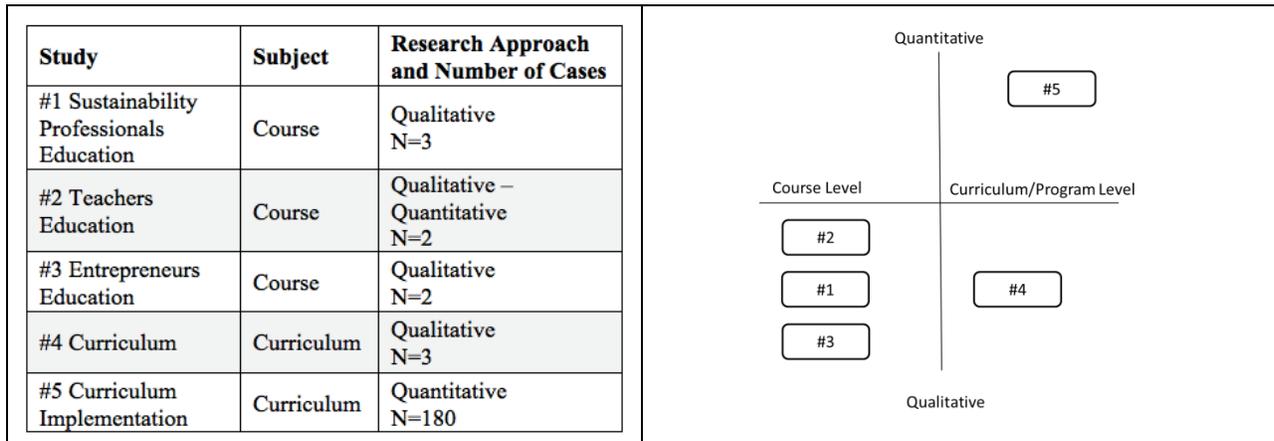


Figure 1: Design features of the project

The selection of cases and courses for the three case studies on the course-level is based on a theoretical sampling approach to contrast relevant categories and their properties (Glaser and Strauss 2017). Courses were selected that display high similarity within cases and high variance between cases, namely:

- Variance regarding the teaching and learning *context* (courses embedded in stand-alone sustainability programs (Study #1); courses as part of disciplinary programs (Study #2); and elective/extra-curricular courses (Study #3))
- Variance regarding the learning *objectives* (variations of competencies composition)
- Variance regarding the *pedagogy* (solution-oriented, collaborative learning; discursive learning; consultative learning)
- Variance regarding the teaching and learning *setting* (real-world vs. classroom and online)
- Variance regarding the *assessment approach* (reflective portfolio vs. in-vivo assessment)

The systematic variance between the selected cases allows for structured insights on competence development in different novel teaching and learning environments.

The fourth case study was conducted on the curriculum level – offering a complementary perspective to the three course-level case studies. This allowed for comparison and contrasting learning processes and outcomes on both levels.

All four case studies were conducted in parallel in two distinct contexts at Leuphana and Arizona State University. Rather than having a different researcher or set of researchers at each location, each case study (and its responsible researcher) conducted research on two corresponding courses, one in each location. For example, the researcher of study #2 (teachers education) studied courses at *both* universities, Leuphana *and* Arizona State University. Among the different cases, we were able to control for both the differences in context and differences in the implementing researchers (and their designs).

Finally, this project included a quantitative comparative study of curricular implementation across a large number of universities (study #5). This allowed for linking findings up the scale and for providing generalizable findings.

Empirical Framework for Data Collection and Analysis

Being able to generalize insights across the five studies required to harmonize the research instruments, drawing on previous research (e.g., Barth, 2015). The result was a shared empirical framework to guide data collection and analysis across the individual studies (Fig. 2).

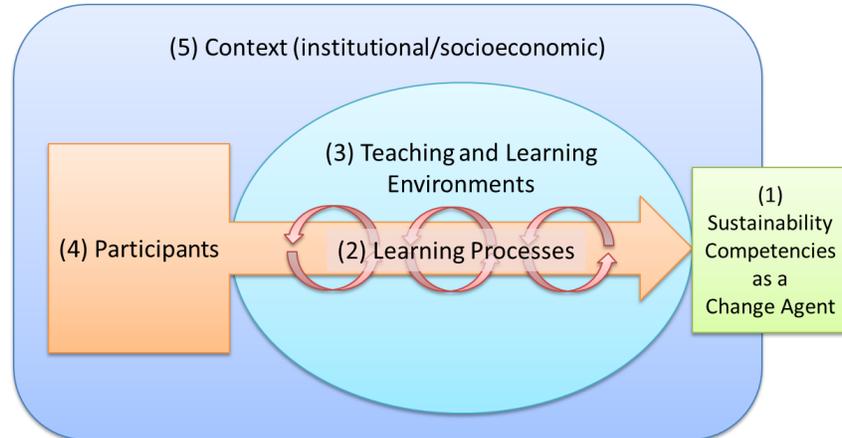


Figure 2: Empirical framework of the project that guided data collection and analysis across the individual studies

The empirical framework is structured into five areas, each of which was further specified through a set of variables:

- (1) Sustainability Competencies: competence in systems thinking, futures thinking, values thinking, strategic thinking, interpersonal/professional skills
- (2) Learning Processes: activities (who/where/when/what) and interactions (how)

- (3) Teaching and Learning Environment: instructor profiles, infrastructure, teaching plan, and the enabling context
- (4) Participants: program entry requirements, demographics, aspirations, past experiences, relevant outside activities, and non-cognitive dispositions
- (5) Context: institutional (formal, informal, resources, support, disciplinary structure, etc.), curriculum (program structure, learning objectives, etc.), socio-cultural context

Variable	Description
1) Change in Competence	
<i>Systems Thinking</i>	Operationalization for specific case study if done officially and for specific research questions of that case. Evidence of change pre versus post on assessments Changes in self-assessed levels of specific competencies Reflections in interviews or focus groups which identified competencies that were developed Traces of competence development identified via observation or textual analysis. (See chapter 6 for more discussion)
<i>Futures Thinking</i>	
<i>Values Thinking</i>	
<i>Strategic Thinking</i>	
<i>Interpersonal</i>	
<i>Problem-Solving</i>	
2) Teaching and Learning Process	
Actual Activities	
<i>Who/where/when</i>	The basic information regarding a teaching and learning unit which is selected for inclusion in the sample. <i>Who is there? Where is it taking place? When and for how long?</i>
<i>What</i>	High level description of the activities that occur in a sampled teaching and learning unit. <i>What is happening during the T&L unit?</i>
Interactions (How)	
<i>Student-Material</i>	Thick descriptions of how the students interact with course materials.
<i>Student-Student</i>	Thick descriptions of how the students interact with each other.
<i>Student-Teacher</i>	Thick descriptions of how the students interact with the instructors.
<i>Student-External</i>	Thick descriptions of how the students interact (if relevant) external stakeholders or guests.
3) Teaching and Learning Environment	
Instructor profiles	
<i>Academic Background</i>	The instructors' academic training as well as past and current research fields and academic positions where he or she has worked.
<i>Non-academic work</i>	Work the instructor has done outside of academia whether while also working as an academic or as a fully independent position.
<i>Teaching experience</i>	The institutions, programs and courses the respective instructors has previously taught, any formal or informal training he or she may have, and his/her educational approach/tradition

<i>Teaching Competence</i>	A competence profile of the respective instructors which includes interpersonal competence, content knowledge and other important skills, from both an objective perspective and the students' perception of the instructor.
Infrastructure	
<i>Physical setting</i>	The physical structure of the settings where the specific course/learning unit takes place.
<i>Virtual (online) setting</i>	The organization of online learning platforms and material (incl. tools to communicate amongst the participants)
Plan for the unit	
<i>Planned sequence of activities (what and when)</i>	What is planned for the specific course/learning unit and in what order. When does each activity take place and for how long (dates and duration). <i>What is the rationale?</i>
<i>Static course material (with what)</i>	The static material instructors or/and students bring to the specific course/learning unit, such as articles, book, movies etc. <i>What is the rationale?</i>
<i>Course/class level learning objectives (what for)</i>	The desired learning outcome(s) of the respective course/learning unit <i>What is the rationale?</i>
Enabling context	
<i>Stakeholders</i>	Internal and external protagonists, who actively participate in the respective course/learning unit and their roles in it.
<i>Problem/Solution Description</i>	Describe the specific sustainability problem or set of problems (or solutions) which are the focus of the course. Should include who and why elements as well. <i>What is the problem and why was it chosen?</i>
<i>Problem & solution framing</i>	Description of how the specific problem (described in the other variable) and/or solutions are framed (introduced, presented, articulated or developed by the students themselves).
4) Participants	
<i>Program entry requirements</i>	The explicit and implicit requirements for taking part in the program. <i>What are the base factors in selecting students for a program?</i>
<i>Demographics</i>	The age, nationality, educational background, sex, ethnicity, socioeconomic status, etc. of the individual students.
<i>Previous Experience</i>	Experiences of the participant which might be relevant to the particular T&L unit; e.g. has worked in this content area or had a positive experience with this learning approach before.
<i>Professional Aspirations</i>	The future hopes/desires of the students both big picture vision and short-term specific. <i>What are the internal motivations which inform the students' efforts and interests during their studies?</i>
Relevant outside activities	

<i>Curricular activities</i>	List and brief descriptions of the courses and curricular offerings the participant is taking simultaneous with the T&L unit of study.
<i>Co- and Extra-curricular activities</i>	Activities engaged in outside of the participant's courses which may or may not be explicitly related to their studies. <i>Are the students engaged in activities which may influence competency development? If so, what?</i>
Non-cognitive dispositions	
<i>Self-efficacy</i>	A student's confidence in her/himself to independently work and problem solve. Both a stable and general trait and a more malleable sustainability related self-efficacy. <i>How do students respond to working independently and carrying responsibility, how do these attitudes develop over their education, and can any relationship be drawn between self-efficacy and competence development?</i>
<i>Comfort with transformational learning</i>	A student's level of comfort or discomfort with learning situations intended to bring about shifts in values or perception. <i>How do students react to transformational learning, and can any connections between these reactions and competence development be drawn?</i>
<i>Attitudes toward sustainability</i>	What model of sustainability does the student support, how does she believe this should be achieved, and what are the goals. <i>In what ways do student attitudes influence their behavior and choices in the program, and what connections can be made to individual competence development?</i>
<i>Ability to self-organize</i>	When being given a goal or task, the ability to recognize work packages, set goals and benchmarks, and monitor time. <i>What connections between self-organization and competence development can be observed, and in what way?</i>
<i>Motivation</i>	Intrinsic drive to accomplish or participate specifically for this T&L unit. <i>What factors influence student motivation, how do these shifts present themselves, and how does this relate to competence development?</i>
5) Context	
Institutional context	
<i>Formal Prioritization</i>	The strategic planning and prioritization of the university/institution/program/unit, which may be operationalized in a variety of forms from mission statements to official policies. (Can be on university and unit level) <i>What is the stated purpose of the university? Of the department? Of the program?</i>
<i>Informal Prioritization</i>	Describe any informal or implicit factors which may impact the importance/influence of the institution/program/unit within the university. (Can be on university and unit level)

	<i>How is the internal priority setting of the program/course within the university T&L culture?</i>
<i>Resources</i>	The available budgets (amount and source of funding) and workloads of the staff. Especially with regards to any specific support for innovative T&L. (Can be on university and unit level)
<i>Faculty support/T&L culture</i>	Support (informal and formal) for faculty to implement innovative T&L formats. <i>Can faculty develop and implement new courses? If so, what are the procedures? Is there staff to help? How are non-traditional course formats viewed by administration and other staff? Are there incentives (e.g. teaching awards)</i>
<i>Disciplinary structure</i>	Description of how disciplines are structured and grouped within the university and sub-disciplines within departments. <i>How separate or interdisciplinary are the departments and programs?</i>
<i>Student recruitment and support</i>	Structures for student recruitment and student support.

Data Collection and Analysis Methods

A wide variety of methods were used for both the collection and the analysis of data within each of the cases and across the project. Development of these approaches was coordinated among the studies but in the end each study developed its own suite of data collection and analysis methods which were best suited to answer their research questions and the specific context and characteristics of the cases under study. Beyond the typical triangulation of methods (Creswell 2009), the empirical framework previously described served as a guide to assure that the methods and analysis were aligned in such a way so as to provide overlapping coverage of all the relevant data.

The methods for data collection included the development of several new approaches, in particularly for competency assessment, were the scholarly literature particularly lags (Redman, Wiek, and Barth 2020b). This ranged from an in-vivo simulation, to an expert rated case analysis. Across several of the cases photovoice was brought into the end of semester focus groups in order to help students to trace their learning processes and better unpack the “black box” of learning (e.g., Konrad et al., 2020). In addition, there was extensive participant and non-participant observation data collected, interviews with teachers, students, and stakeholders, document analysis and surveys to collect data ranging from demographics to attitudes and motivations. Several systematic literature reviews were conducted as part of the project including being the focus of an entire study. In this study the case survey method was applied for the first time to research in ESD (Weiss et al., 2020).

The bulk of the data which was generated was of a qualitative nature. For the quantitative data from the assessments and surveys mostly descriptive statistics was utilized for analysis with some inferential techniques such as t-tests. The qualitative data was analyzed following a grounded theory approach (Corbin and Strauss 1990). Codes and categories were typically derived inductively (initially). These were then compiled into a codebook, with some coordination and alignment of codes across the studies. After the initial inductive coding, a more deductive process was used to process the large quantity of qualitative data which had been generated. Axial coding

was used to find patterns in the learning process of the students which linked to characteristics of the courses or curriculum under investigation. Table 3 summarized the collection and analysis methods used in the project.

Table 3: Summary of Data Collection and Analysis Methods

Collection Method	Analysis Methods Used on this Data	Chapters	Studies
Competency Assessments	Descriptive and inferential statistics	Chapters 4	(Brandt et al. 2019)
Focus Groups	Grounded Theory	Chapters 3,4,7	(Konrad, Wiek, and Barth 2020; Brandt et al. 2019)
Interviews	Grounded Theory	Chapters 3,4,7	(Konrad, Wiek, and Barth 2020; Brandt et al. 2019)
Observations	Grounded Theory	Chapters 3,4,7	(Konrad, Wiek, and Barth 2020; Brandt et al. 2019)
Document Analysis	Descriptive	Chapters 3,4,5,7	(Konrad, Wiek, and Barth 2020; Brandt et al. 2019)
Survey	Descriptive and inferential statistics	Chapter 4	(Brandt et al. 2019)
Case Survey	Descriptive and inferential statistics	Chapter 8	(Weiss and Barth 2019)

Conclusions

This research utilized a range of methods from class observations to focus groups to rigorously seek to empirically link specific teaching and learning formats (and curricular elements) with student development of key competencies. Herein I will present the results from the work of our five PhDs whose topics include teacher education, project-based learning courses, entrepreneurship, comparing curriculums, and a case survey of curriculum implementation globally. The team has been working diligently from the get go to synthesize this extensive body of work. Key moments of learning were identified and through rich data sets linked back to the specific characteristics of the course and curriculum which fostered those moments. The scale

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