Competence Across Curricula: A Comparison of Three Graduate Sustainability Programs

Jodie Birdman, Matthias Barth, Daniel Lang

Working Papers in Higher Education for Sustainable Development Series

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Editorial

"Working Papers in Higher Education for Sustainable Development" is a series dedicated to delivering 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 own 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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Abstract

English

As fulcrums for knowledge generation, higher education institutions take a key role in sustainable transformation. Part of their responsibility is the education of future change agents. These leaders will need competencies associated with effective complex problem solving, but evidence-based insights on how to develop and implement powerful competence-oriented curricula is still lacking. This comparative case study examines the curricula of three existing graduate sustainability programs. These programs, the Leuphana Master of Sustainability Science, the Arizona State University Sustainability M.A./M.S., and the Global Sustainability Science Master show three approaches to sustainability education embedded in local contexts. To inform the data-driven insights from this research, this working paper provides a detailed description of the education histories and contexts of each case, as well as an overview of the overall research design. This contextual information both enriches the thick data of each case and increases transparency of the research for better understanding of related findings.

Key words: higher education, sustainability, curricula, project based learning, experience based learning, case study method

Deutsch

Als Dreh- und Angelpunkt für die Wissensgenerierung spielen Hochschuleinrichtungen eine Schlüsselrolle bei der nachhaltigen Transformation. Teil ihrer Verantwortung ist die Ausbildung zukünftiger Change Agents. Diese zukünftigen Führungskräfte benötigen Kompetenzen, die mit einer effektiven Lösung komplexer Probleme verbunden sind. Evidenzbasierte Erkenntnisse zur Entwicklung und Implementierung wirkungsvoller kompetenzorientierter Lehrpläne fehlen jedoch. Diese vergleichende Fallstudie untersucht die Lehrpläne von drei Nachhaltigkeitsprogrammen für Hochschulabsolventen. Diese Programme, der Master of Sustainability Science der Leuphana Universität Lüneburg, der Sustainability M.A./M.S. der Arizona State Universität (ASU), und der gemeinsame Global Sustainability Science Master der Leuphana Universität und der ASU, zeigen drei Ansätze zur Entwicklung von Nachhaltigkeitskompetenzen mit der Einbettung in lokale Kontexte. Um die datengetriebenen Erkenntnisse aus dieser Forschung zu informieren, bietet dieses Arbeitspapier eine detaillierte Beschreibung der Bildungshistorien und -kontexte jeder Fallstudie, sowie einen Überblick über das gesamte Forschungsdesign. Diese Kontextinformationen bereichern sowohl die Beschreibung der Fallstudien durch ein detaillierteres Level der Tiefe und Breite, als auch die Transparenz der Forschung zum besseren Verständnis der damit verbundenen Ergebnisse.

Key words: Hochschulbildung, Nachhaltigkeit, Curricula, Projektbasiertes Lernen, Erfahrungsorientiertes Lernen, Fallstudie

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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.

The curriculum case study

The number of dedicated sustainability programs is growing , but they remain a niche degree opportunity (Weiss & Barth, 2019). Leuphana and Arizona State University have, separately and together, developed three Master of sustainability science programs with similar goals and outcomes, but slightly different approaches to achieving these. In order to better understand not only the connection between individual classes or pedagogical approaches and competence, but also the influence of curriculum as a whole, a longitudinal comparative case study (Yin, 2009) was conducted. This two-year study links student experiences with curricular design with a particular focus on specific instructional elements.

Case study research and the need for case documentation

Despite the growing need for empirically sourced insights on education for sustainable development, the majority of research surrounding specific interventions and pedagogical approaches in higher education takes the form of narrative case studies (Barth & Thomas, 2012). While it is possible to synthesize general insights from such studies, specific, evidenced-based findings would strengthen both understanding and praxis. It is to this end that the EFCA project incorporates multiple case studies, including a curriculum level comparative case study, which is described in this paper.

1.2 Overview of the comparative curriculum study

This case study takes place at Leuphana University in Lüneburg, Germany and Arizona State University (ASU) in Tempe, USA. It examines the curricula of three sustainability Master's programs. These are the Leuphana Sustainability M.Sc.[1], the ASU Sustainability M.A.[2]/M.S.[3], and the Master of Global Sustainability Science (GSS) program[4], which is a cooperation between Leuphana and ASU. These programs were selected due to specific similarities and differences in curricula and expected outcomes (Figure 1).

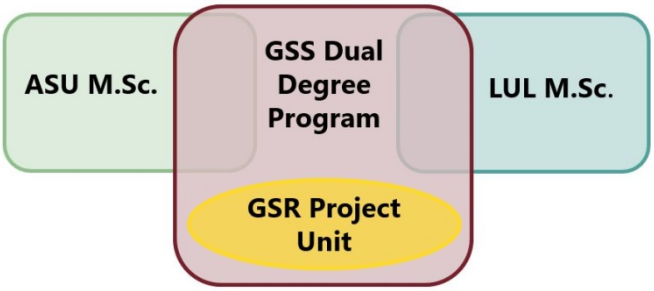

Figure 1: Curricular overlap in the comparative cases

This research takes the macro and micro level into account by collecting data from both the curriculum perspective and the individual student perspective, and then bringing them together to synthesize insights (Figure 2). In order to do this, multiple data sources were used. For the macro level, course and program-related documents were collected and analyzed to both build an overview of the three curricula and to identify courses and activities relevant to this study. Interviews with curriculum designers (when available) add depth to the understanding of the intention behind the curricular structure.

Data from the micro level comes from in-vivo observations, instructor interviews, and student interviews. The instructor interviews focused on the courses and activities they design and teach. The student interviews were combined with a self-assessment tool developed to assist student reflection and recall of curricular experiences. These interviews focus on the students' individual learning journeys, which form the narrative of this study. Observation notes are used to

[1] https://www.leuphana.de/en/graduate-school/master/course-offerings/sustainability-science.html
[2] https://webapp4.asu.edu/programs/t5/majorinfo/ASU00/SUSUSTMA/graduate/false
[3] https://webapp4.asu.edu/programs/t5/majorinfo/ASU00/SUSUSTMS/graduate/false
[4] Leuphana: https://www.leuphana.de/graduate-school/master/studienangebot/global-sustainability-science.html; ASU: https://webapp4.asu.edu/programs/t5/majorinfo/ASU00/SUGSUSSMS/graduate/false

contextualize information from the interviews. The whole is brought together with student focus groups, in which students in the round are able to discuss their whole curricular experience. The rich body of data supports curricular level insights with connection to specific activities and learning moments.

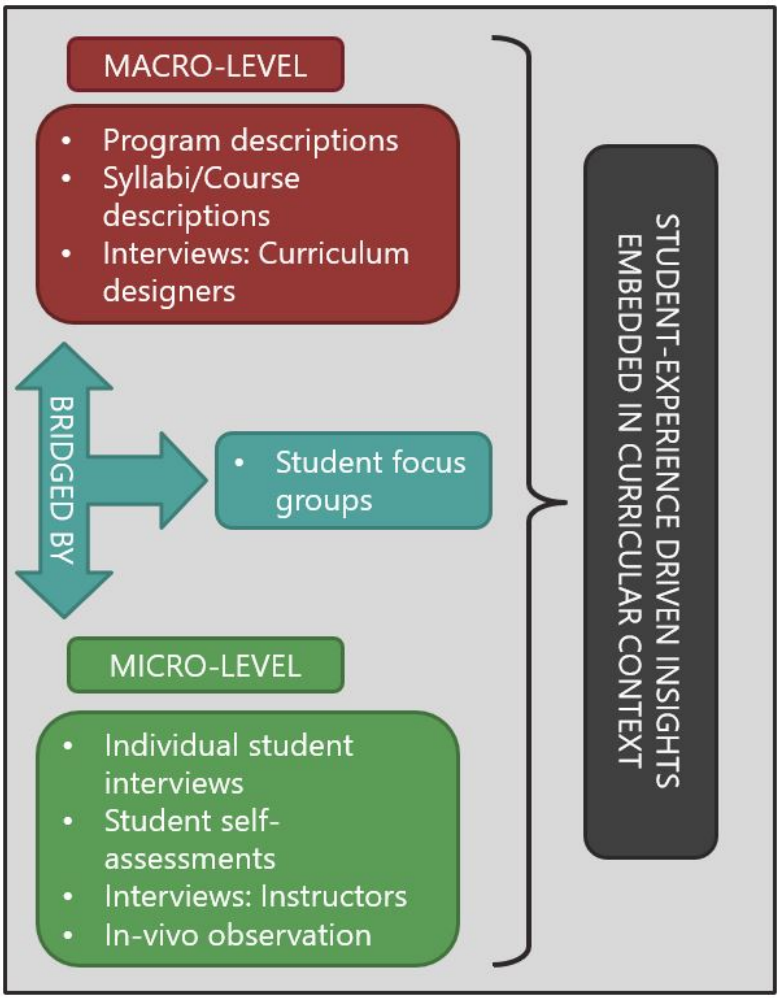

Figure 2: Data collection design

1.3 Acknowledgement

We would like to thank our colleague Guido Caniglila for his input and support on the design of this research, as well as all the instructors, staff, and students at Arizona State University and Leuphana University Lüneburg for their support and participation. This research would not have been possible without their input and trust.

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Part II

Description of cases

2.1 Case 1: The Leuphana Master's Degree

The Sustainability M.Sc. at Leuphana is a four semester, 120 European credit graduate program open to students from a range of disciplinary backgrounds. It aims to prepare students to integrate sustainability with their future path of choice, whether that is in academia, business, governance, or non-profit work.

Context: Master of sustainability studies in Germany

As part of the Bologna Process, most universities in Germany adopted a structure based on undergraduate (Bachelor) and graduate (Master) degrees in the 2000s. Previously, Universities awarded *Diplom* or *Magister* degrees, depending on the field. These were the equivalent of post-graduate, pre-doctoral degrees. The conversion process included the adoption of the European Credit Transfer and Accumulation System (ECTS) as part of an agreement to simplify the transfer of courses and degrees between European institutions. One credit in the ECTS is the equivalent of 25 to 30 hours, with a standard academic year consisting of 60 ECTS credits, or 1500-1800 hours of work.

Those wishing to attend university in Germany must have completed university preparatory school and the associated exam (Abitur) or equivalent. Students apply for the degree program they are interested in, and generally most or all classes will be specific to that degree program or the faculty in which that program is embedded. Most universities in Germany are public, and student fees per semester vary from institution to institution but are generally under €500. These fees pay for student services such as public transportation tickets, funding for student initiatives, and similar. While Germany has adopted an undergraduate and graduate degree format, it is still the norm that students remain at university until they have completed a Master's degree or equivalent.

Sustainability is still an emerging field in German universities. Undergraduate sustainability-oriented degrees in business, engineering, computer science, and natural science degrees are available at several universities. Graduate degrees are less common. Several German universities offer degrees under the title of sustainability, but with a specialization such as sustainable education, sustainable chemistry, sustainable business models, etc. At the date of this study, Leuphana was still the only university in Germany offering sustainability as its own graduate degree program, and it is the only German university with a faculty of sustainability.

Leuphana University Lüneburg

Leuphana is a mid-sized university in Germany with 9888 students enrolled in Fall 2018[5]. Leuphana was founded in 1946 as a teaching college and converted to a university in 1989. In the years following the university underwent developmental transformations, including the implementation of the Bologna process in 2005 and a reconceptualization and re-orientation as the current Leuphana University in 2007, with the graduate school opening soon after in 2008. Leuphana is one of the few institutions worldwide where it is possible to study sustainability from Bachelor to doctoral level. In addition to sustainability, Leuphana also offers graduate programs in governance, law, humanities, management, entrepreneurship, and education.

Sustainability extends beyond a dedicated department at Leuphana. It is a foundational concept for the campus, which integrates ecological, social, and business aspects of sustainability through landscaping, student initiatives, social engagement, and business partnerships. Curricular and non-curricular initiatives such as music festivals[6], student conferences[7], and course innovation are part of Leuphana's reputation. Leuphana is also unique in Germany, in that all undergraduate students are required to spend their first semester in a shared, sustainability-oriented set of courses, resulting in all undergraduate and continuing students having some curricular experience with sustainability. Leuphana's interdisciplinary approach is key to graduate curricula in the form of another education innovation: *Complimentary studies*[8]. The driving concept is to encourage graduate students to explore topics they find interesting and relevant, but which are not part of their specific degree's curriculum. These classes are open to all majors, are generally 1-2 credits, and are an opportunity for students to learn from and work with students in other majors and faculties while introducing concepts and methods from a range of disciplines. All graduate degrees at Leuphana require 15 credits of complimentary studies.

The study period at Leuphana is divided into two semesters per year. The Winter Semester begins in mid-October with classes running until the beginning of February. After this there is a "lecture free period" (vorlesungsfreie Zeit) in which exams take place and final projects and papers are to be completed and handed in. The Summer Semester begins in April with classes running to the beginning of July, after which comes another lecture free period.

Graduate programs generally take the form of four semesters with 120 credits in total. Of these, 60 credits are dedicated to major-specific courses, 30 credits are dedicated toward the Master's dissertation (including a 5 credit Master's Forum class), 15 credits are in *meta-perspectives*, and 15 credits are in complementary studies. Meta-perspectives courses are program specific, and they investigate the foundations and practices of research in that field. Complimentary studies cover a range of general academic topics with the goal of broadening the students' perspectives on science and encouraging cross-discipline collaboration and contact.

[5] https://www.leuphana.de/en/university.html
[6] https://lunatic-festival.de/ueber-uns/
[7] https://www.leuphana.de/en/college/first-semester/conference-week.html
[8] https://www.leuphana.de/en/college/study-program/complementary-studies-programme.html

Course attendance is expected but not mandatory. Grades rely on a final project and/or test at the end of the semester. Many classes are divided into a lecture/seminar format, in which students must register for both a lecture and an associated course with a student-producible focus. These producibles are usually in the form of group work culminating in a presentation and/or report. Courses which do not take the lecture/seminar format are often a combination of frontal instruction, group discussion, and small group activities or project work.

Figure 3: Leuphana general design for a Master's degree (Leuphana Universität Lüneburg)

The Leuphana sustainability M.Sc.

Origin of the Program

The Sustainability M.Sc. was developed as part of the process of creating the graduate school at Leuphana. The concurrent focus on sustainability and transformation of the university made the creation of a Master of Sustainability a clear goal from reconception. As a result, Leuphana offers a full sustainability degree pathway with accredited Bachelor's, Master's, and doctoral degrees. The M.Sc. was designed to place equal emphasis on the natural sciences and *human sciences* which Leuphana defines as economics, social sciences, and politics, and it includes a multi-semester transdisciplinary research project. The program is based on the original *Diplom* program and is seen as a logical continuation of undergraduate work. The outline was developed by the faculty of sustainability, and the first students began their studies in October 2008.

Program requirements

The Leuphana Sustainability M.Sc. accepts applicants who hold a Bachelor or equivalent degree in a broad range of fields including, but not limited to, the natural and social sciences.[9] All applicants able to show experience in a subject related to environmental or sustainability science and who are interested in a research oriented sustainability graduate degree program are considered. Because

[9] More information about application requirements and procedures can be found here: https://www.leuphana.de/en/graduate-school/master/course-offerings/sustainability-science.html

the program is taught in German and English, applicants must provide proof of language proficiency in both areas.

Goals and Outcomes

The program is designed to bring students from diverse disciplinary backgrounds together and build interdisciplinary and transdisciplinary capacities founded on a sustainability science basis. By the time students have successfully completed the program they will have graduate level academic knowledge in a range of areas of the natural and human sciences, as well as experience working in transdisciplinary project teams. Students are able to select and increasingly specialize their learning paths, which results in graduates with a shared sustainability foundation and individualized specializations. The degree program explicitly aims to enable students to act as change agents in a broad range of fields including business, consulting, NGOs, politics, economics, and science. Successful completion of the program results in a Master of Sciences degree.

Program description, Curriculum structure

Like all graduate programs at Leuphana, the Sustainability M.Sc. is a four semester, 120 credit graduate program (See Figure 4). Students take a combination of required classes and *mandatory electives*, and complimentary studies, making each study path potentially individual (See Table 1). The mandatory electives are in the natural sciences and human sciences. Complimentary studies classes allow students to both explore new areas and deepen their existing knowledge.

Specifics, unique characteristics

At the heart of the sustainability M.Sc. lies a transdisciplinary research project unit (Vilsmaier & Lang, 2015). This unit spans two semesters and is worth a total of 20 credits, or 1/6 of the total program. Students choose from a selection of topics which are attached to existing research centers or research projects at Leuphana. In these project groups they work together to conceptualize and implement a sustainability project together with university staff and local stakeholders and experts. Examples of past projects have included working with the Lüneburg City Council on an urban sustainability plan and creating and launching a sustainable consumer product. This approach provides students with diverse disciplinary backgrounds and foci a forum to deepen and use their skills and knowledge collaboratively in a solution-oriented, praxis focused setting.

The program design is cumulative, with each semester building on the previous. The first semester consists of a required course in sustainability science, two mandatory electives in the natural sciences, two mandatory electives in the human sciences, and five credits in complimentary studies: philosophy of science. The courses are structured with the goal of ensuring that students from the social sciences are familiar with foundational sustainability texts and methods from the natural sciences and vice versa for students from the natural sciences. This provides students the opportunity to form a shared, interdisciplinary knowledge basis in preparation for the project semesters.

The following semesters follow in a similar manor with the addition of the transdisciplinary research project. Students have the choice to either focus on human or natural sciences or continue to take classes in both areas. Courses in the complimentary studies allow for further customization and exchange with students outside of the faculty of sustainability.

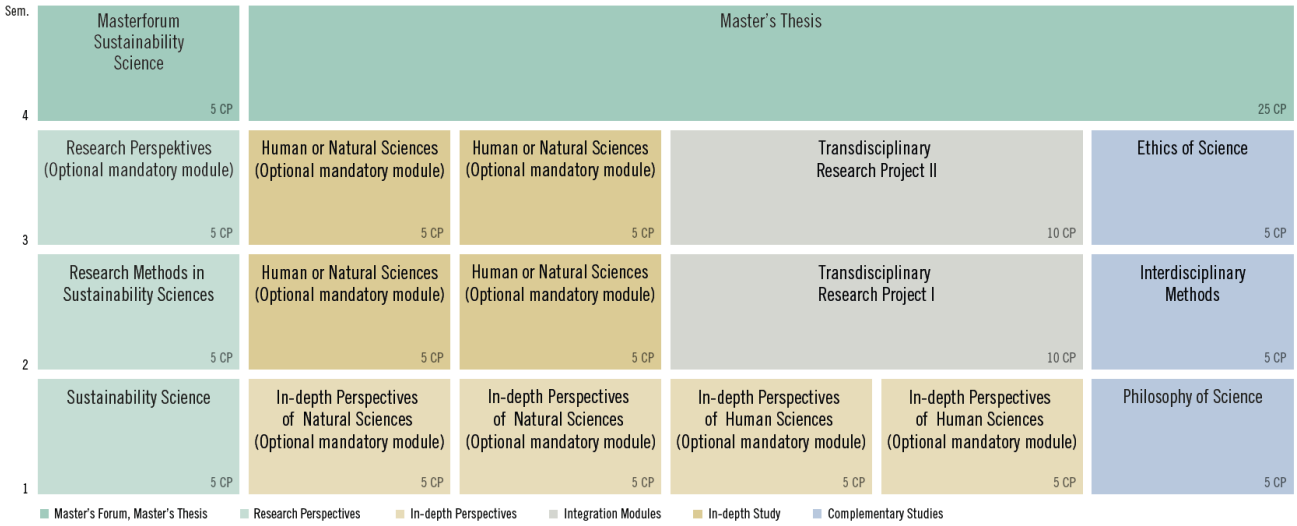

Figure 4: Curriculum overview: Leuphana Master of Sustainability Science (Leuphana Universität Lüneburg)

Table 1: Overview of mandatory electives

	Natural Sciences	Human Sciences
Semester 1	• Ecosystem responses to Chemical Pollution • Earth Systems and Climate Change • Geochemical Aspects of Compounds in the Environment and Sustainable Chemistry	• Sustainability Communication • Market-oriented Sustainability Management • Sustainability Governance
Semester 2	• Conservation Biology • Ecosystem Processes: A Biogeochemical Perspective • Geochemical Parameters and Sampling Strategies • Advanced Analytical Chemistry	• Theories and Perspectives of Sustainability Communication • Sustainability Performance Measurement, Management, and Communication • Sustainability Economics • Sustainability, Digital Media, and Information Society • Sustainability, Governance, and Law
Semester 3	• Advanced Sustainable and Environmental Chemistry • Sustainable Energy • Macro ecology and Global Change Biology • Models in Global Change Research	• Social Ecology: Conceptual and Methodological Principles, Social-Ecological Space Research • Sustainability, Culture, and Education • Sustainability and Social Developments

The Leuphana M.Sc. cohort

The 2017 sustainability science M.Sc. cohort at Leuphana had 38 students. They came from a variety of undergraduate backgrounds which can be broadly categorized as natural sciences, social sciences and business/finance. The students held undergraduate degrees from Leuphana, other German institutions, and some universities abroad. All students were German speakers. While most students continued directly from their undergraduate studies, there were also returning students with work experience and/or children in the cohort.

Informal discussions with students in October and November of 2017 revealed some common reasons for enrollment. These included interest in the transdisciplinary research project, Leuphana's reputation for sustainability, comparatively low class sizes for the German context, and Leuphana's academic reputation. Personal reasons for choosing a sustainability graduate program came from a desire for knowledge and skills to bring about sustainable changes in the world and society.

2.2 Case 2: The ASU Master of Arts/Science

The Arizona State University Sustainability Master of Science and Master of Arts program is a four-semester graduate program comprising of at least 37 U.S. credits. The program is open to students from most academic backgrounds holding a valid Bachelor's degree or equivalent. It is targeted at high-achieving students interested in a research –oriented degree. It aims to prepare students for success in academic and non-academic fields as sustainability experts.

Context: Master of sustainability studies in the U.S.

The higher learning landscape in the United States is varied, but with some aspects outlined at the national level such as accreditation. Persons wishing to study in the United States will generally need a valid certificate of completed secondary school (or similar) and to have participated in one of several university entrance exams. Individual universities have the freedom to set the minimum standards for enrollment. All universities are at least partially funded through student tuition and through alumni donations, including public (state funded) universities. This has led to some level of competition between institutions. Additionally, the cost of studies is set by the individual institution with variation in fees based on numerous factors such as student residence, eligibility for assistance, and government programs.

The U.S. credit system differs from the Bologna concept and can also vary from university to university. The most common system standardizes each credit as corresponding to one hour of instructional time per week, meaning that a student taking 10 credits can expect to spend 10 hours each week in lectures, lab work, or other instructional activities. Additional workload outside of class varies, as does the number of credit hours required for a full-time study program.

In general, students pay a flat fee for enrollment, and then pay additionally per credit. Many students in the U.S. fund their studies through scholarships, grants, or student loans. Funding may also be available as a benefit of working for the university. This is especially true at the graduate

level. Graduate students will often take on teaching assistant or research assistant positions as a way to have their semester fees waived and sometimes earn supplementary income.

Sustainability is an emerging field in the U.S., with dedicated programs growing in number but still uncommon. Much like Germany, most programs have a subject specific focus such as ecology, business, resource management, etc. from a sustainability perspective. Arizona State University was the first post-secondary institution in the U.S. to create a dedicated department of sustainability and to offer sustainability as an independent degree program. It offers accredited sustainability Bachelor's, Master's and doctoral degrees.[10]

Arizona State University

ASU is the largest public university in the United States with a total of 111,249 students enrolled in Fall 2018[11]. It is also a leading university in Sustainability and sustainability research. ASU approaches sustainability from multiple angles, including campus infrastructure and policy, sustainability courses offered in multiple degree programs, and community and business partnerships. It offers a wide array of graduate programs both online and in person with 27 independent Master's programs under the topic of sustainability. Completion criteria are specific to the program, as are outcomes. Full time graduate studies require enrollment of at least 9 credit hours per semester.[12]

The study year at ASU is also arranged with a variety of options. In general, studies start in the Fall Semester, which begins in mid-August with classes running through the first week of December. After classes end, there is a two-week exam period. The Spring Semester begins in middle of January with courses running through to the end of April, followed by two weeks of exams. Additionally, a Summer Semester is available from mid-May to the beginning of August. Each semester is divided into three sessions. When a class and the associated exam takes place is dependent on the session. Required courses usually happen in the Fall and Spring Semesters. Attendance and grading policy varies between courses and programs, but required attendance is not unusual. Most graduate classes require a paper, presentation or exam in the middle of the semester and a second at the end of the semester. Classes may also have multiple graded student deliverables throughout the semester. Attendance and participation are also usually part of student assessment.

The ASU Sustainability M.A./M.S.

Origin of the program

The Sustainability M.A./M.S. at ASU was launched in its current form in fall 2014 following a redesign. The reconceptualization and creation process was undertaken by curriculum designers, instructors, and students of the School of Sustainability (SOS). The faculty identified that the existing need for sustainability actors both in and outside of academia required a new approach, and thus

[10] More information here: https://schoolofsustainability.asu.edu/

[11] https://www.asu.edu/about/facts-and-figures

[12] Further information including caveats regarding individual funding, sponsorship, and visa status can be found here: https://issc.asu.edu/departments/students-f-j/full-time-enrollment-requirements

conceptualized a program that focused on first developing the students' capacity and then providing the students with a wide array of project-oriented, competence-oriented options. Key competence-oriented instruction is encouraged. The program is in a continuous process of transformation due to encouragement of experimental course formats and ties to existing projects in research and industry.

Program requirements

Applicants must have a Bachelor's degree or higher from a recognized institution and a grade point average of 3.25 or higher (U.S. grading scale 4.00 = perfect). Additionally, applicants will need to submit their Graduate Record Examination (GRE) score, three letters of recommendation, a statement of intent, and proof of English language proficiency.

Goals and outcomes

Students who successfully complete this program will earn a Master of Science or a Master of Arts degree, depending on whether their selected courses were oriented toward the natural or social sciences, respectively. Additionally, students can expect an approach that focuses on solution and research orientation. The program aims to develop academic and technical skills that will be necessary for success in academia, business, and elsewhere. According to ASU, 100% of graduates find employment, and 86% of those are in sustainability.[13]

Program description, curriculum structure

The Sustainability M.A./M.S. comprises a minimum four semesters and 37 credit hours (Table 2). In the first semester students attend a set of *core courses* with the goal of building a shared base for knowledge and praxis, as well as cohort cohesion and identity. Semesters two and three allow students to choose from a range of over 100 possible electives in multiple faculties. The final semester consists of either writing a thesis or writing a scientific paper and a course intended to support this endeavor. Additional support comes from a one-credit graduate skills class which is required every semester, and which is also open to doctoral students. Most available classes are three credits and taught in person, though some online courses are available. This structure is intended to simultaneously allow students to choose a study path best aligned with their interests and future goals while maintaining an identity as a SOS sustainability agent.

Table 2: Overview of ASU Sustainability M.A./M.S. curriculum with credit load

4	Thesis or Scientific paper (6)		Synthesis for Sustainability Research (3)	Community of Graduate Student Scholars (1)
3	General Elective (3)	General Elective (3)	Optional Elective (3)	Community of Graduate Student Scholars (1)
2	Normative Elective (3)	Methods Elective (3)	General Elective (3)	Community of Graduate Student Scholars (1)
1	Perspectives on Sustainability (3)	Research Design and Methods for Sustainability (3)	Social-Ecological Technical Systems (SETS) (3)	Community of Graduate Student Scholars (1)

[13] https://schoolofsustainability.asu.edu/careers/employment-data/

Specifics, unique characteristics

The M.A./M.S. first semester design shows an innovative approach to graduate education in both content and structure. Instructors in the first semester outlined and designed their respective courses collaboratively, with the intention that the students would move through thematic units, and the readings and assignments from each class would support the other classes without repetition. The courses include a research design and methods class which focuses on ethics, ontologies, and epistemology in preparation for work in trans- and interdisciplinary teams, and a Social-Ecological-Technical-Systems (SETS) class specifically conceived and designed to help sustainability graduate students broaden their systems thinking competence and navigate the diversity and complexity of systems concepts and frameworks. As a companion to these classes, a Perspectives on Sustainability course was designed. This course originally was intended to provide informational support but was re-conceptualized by the instructor of the observed cohort to expand students' abilities to reconcile discordant concepts of sustainability, support them in complex problem analysis and solutions, and expand their key competencies. Students also take part in a one-credit Community of Scholars class which addresses graduate students' skills and dealing with university infrastructure. Because this class is required every semester, it ensures that each cohort has contact with other cohorts so that peer-to-peer learning can take place. The final semester required Synthesis for Sustainability research course book ends with the first semester courses, in that it aims to help students focus their knowledge in order to ascertain and disseminate their research findings.

Between the first and last semester, the students have the freedom to choose from a range of accepted electives. These are divided into normative electives (three credits), methods electives, (three credits) and general electives (10-13 credits). Instructors at SOS are encouraged to utilize learner-centric pedagogies and especially project-based learning (Wiek, Xiong, Brundiers, & van der Leeuw, 2014). Some courses are offered repeatedly, and there are also new classes developed and available every semester at the instructors' discretion. These courses are often tied to current research and/or business collaborations.

The ASU M.A./M.S. cohort

The 2017 ASU M.A./M.S. cohort had seven students. Six students were returning professionals with work experience outside academia, and one student was continuing directly from a Bachelor's degree. The cohort included local and out-of-state students and one international student. All students began the program with financial support in the form of either a research assistant position, a teaching assistant position, or employer sponsorship. All seven students agreed to initial conversations about their goals in the program, and reasons for studying sustainability included a desire to improve the world, a desire for meaning in work, the hope that a graduate degree would lead to better employment and earning opportunities, and interest in making a positive impact in their next career step. They chose ASU due to its reputation and connections in sustainability and, for some, because of ASU's location. Students' backgrounds included natural sciences, public infrastructure, business and project management, social sciences, and the arts.

2.3 Case 3: The Global Sustainability Science Master's Program

The Global Sustainability Science Master's program (GSS) is a cooperative degree program developed and offered by Leuphana and ASU. It is the only dual degree international sustainability program at this time. It combines elements from both universities for a unique program intended to prepare students for future leadership positions in sustainability.

Context: A shared graduate program

Education research collaboration

Leuphana and ASU have a history of sustainability education and research collaboration. Together they created an innovative learning project called the *Global Classroom* (Wiek et al., 2013). The project ran in 2013 and again in 2014, and it offered students at both institutions the opportunity to combine online and hands-on learning focused on urban systems and sustainable solutions in both locations[14]. Work on this project laid the groundwork for the Center for Global Sustainability and Cultural Transformation (CGSC), which launched in 2015. The CGSC has continued cooperation, including the development and launching of a cooperative Master of Sustainability program.

The Global Sustainability Science Program

Origin of the program

After their initial experiences with the Global Classroom, the researchers and instructors involved with the project expanded their collaboration to create a complete graduate dual degree program. The focus on sustainability solutions in urban systems became the Global Sustainability Research (GSR) unit around which the program was built. Instructors and curriculum designers at Leuphana and ASU worked together to develop a two-year program which bridged differences such as the Bologna credit system and the U.S. (specifically ASU) credit system, degree requirements, and the program timeline. Institutional factors such as student funding, coordination between instructors, student support for academic processes such as enrollment and course registration and negotiating the different semester timelines are part of the continual development of the GSS program. The result is a graduate program which takes place at, fulfills the requirements of, and results in a graduate degree from both institutions. The first cohort of the GSS began their studies in Fall 2015.

Program requirements

The GSS program requires all students apply to both Leuphana and ASU, and students must be accepted at both universities.[15] A maximum of 20 students total (10 at each campus) can be accepted each year. In addition to the general requirements at Leuphana and ASU, there is also a points-based criteria system for potential applicants. Students must have an undergraduate degree with at least 60 ECTS (or equivalent) in disciplines relevant to the GSS. Points are awarded based on

[14] For more on this project see Caniglia et al. (2016), and Caniglia et al. (2017).

[15] Full admission requirements can be found at https://www.leuphana.de/fileadmin/user_upload/grad_school/files/2Master/Infoblaetter/EN/EN_Application_Selection_GSS.pdf

final grade in the applicant's undergraduate degree, letter of motivation, experience abroad, volunteer activities, practical experience, and selection interview.

Goals and outcomes

The GSS program was developed to foster key competencies for sustainability while combining praxis orientation, educational rigor, and international collaboration. Students in the GSS work on real-world problems in international, inter- and transdisciplinary teams, and they do so in multiple contexts while benefiting from the study possibilities and curricular support of two leading universities in sustainability. During their studies, students have the opportunity to work with and learn from experts in business, consulting, and public administration. Students graduating from the GSS will receive a Master of Sustainability Science from both Leuphana and from ASU. Completion of the GSS is intended to prepare students for leadership positions in public, private, and international organizations.[16]

Program description, curriculum structure

The GSS program (Figure 5 and Table 3) blends courses from the Leuphana M.Sc. and the ASU M.A./M.S. Additionally, it includes an experimental education approach intended to foster the solution oriented, transdisciplinary skills and sustainability competencies needed by future sustainability change agents. The program shares curriculum and courses with both aforementioned programs. Couched within that curricula is a four-phase transdisciplinary research project that spans over three semesters. Students begin their studies at their respective home universities. The second semester takes place at Leuphana, and the third semester takes place at ASU. The final semester is then spent writing the results of their research in a scientific paper at the students' respective home universities. Each semester the students take GSS specific classes and classes shared with the sustainability cohort at that institution.

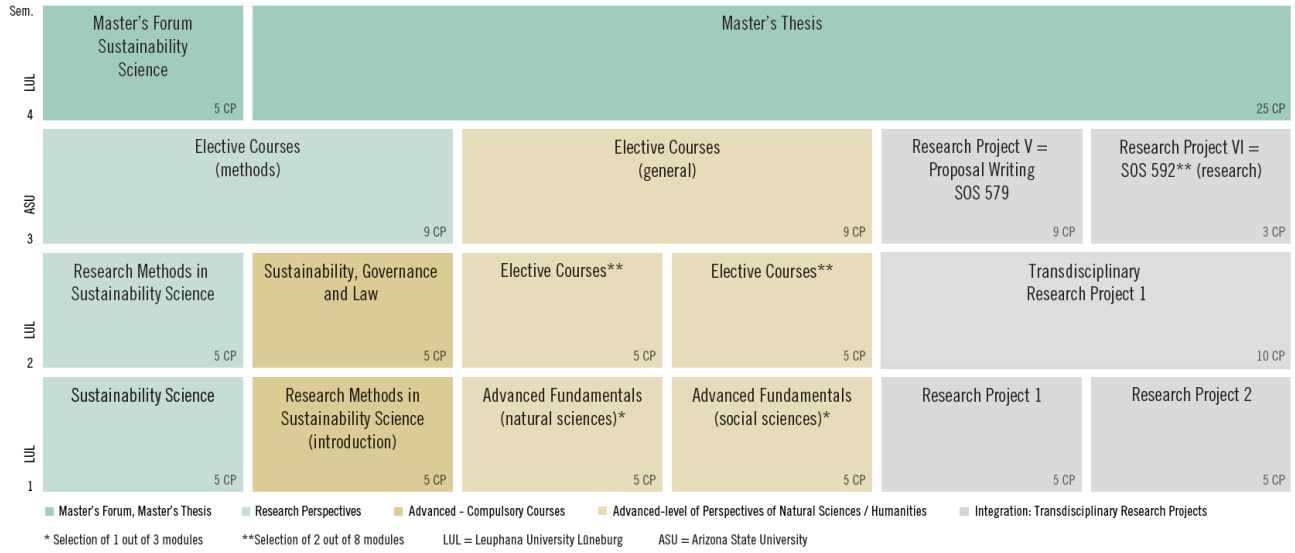

Figure 5: Curriculum overview: Global Sustainability Science (Leuphana cohort) (Leuphana Universität Lüneburg)

[16] https://www.leuphana.de/en/graduate-school/master/course-offerings/global-sustainability-science.html

Table 3: Curriculum overview: Global Sustainability Science (ASU cohort)

4	Scientific paper (6)			Synthesis for Sustainability Research (3)		Sustainable Research Perspectives (1)	
3	Methods Elective (3)	General Elective (3)	General Elective (2-3)	Sustainable Research Perspectives (1)		Transdisciplinary Research Project (3)	
2	Research Methods in Sustainability Science (5 ETCS)	Sustainability, Governance, and Law (5 ETCS)		Elective (5 ECTS)	Elective (5 ECTS)	Transdisciplinary Research Project (10 ECTS)	
1	Perspectives on Sustainability (3)	Advanced Sustainability Problem Solving (3)		Social-Ecological Technical Systems (SETS) (3)		GSS Perspectives (1)	Sustainable Research Perspectives (1)

Specifics, unique characteristics

The GSS is both similar to and unique from the Leuphana M.Sc. and the ASU M.A./M.S. The first semester of the GSS depends on where the student begins their studies, as the students participate in most of the same required classes as the other sustainability Master students. One notable difference is a solution-oriented research class based on the key competencies and offered at both universities. At ASU this class replaces the M.A./M.S. research methods class, and at Leuphana it replaces one of the required electives. At Leuphana the students also take the Global Sustainability Research (GSR) 1 unit, which is formed around the experience based learning framework (Caniglia et al., 2016) used in the Global Classroom. The GSR project continues directly to part two during the lecture free period with the arrival of the ASU based students. During this time, the students form their research project groups, go through an intensive unit on teamwork and collaboration, and they develop their research proposals for the following semesters. The GSR then continues through semester two at Leuphana and semester three at ASU. A more detailed description can be found in Konrad, Wiek, and Barth (2019). Aside from the GSR unit, the second, third, and fourth semesters of the GSS overlap with the other sustainability graduate programs at Leuphana and ASU.

The GSS cohort

The 2017 GSS cohort had ten students at Leuphana and one student at ASU. All students either continued directly from their Bachelor studies or continued after taking a gap year. Of the Leuphana cohort, eight students were German speakers. One student had also participated in the Global Classroom. The undergraduate backgrounds of the students were similar to those of the other programs, with natural sciences and business most strongly represented. All students agreed to initial conversations to learn more about their motivation for choosing the GSS program. All students mentioned an interest in sustainability and the desire to do meaningful, impactful work in the future. More relevant, they chose the GSS for the chance to earn two degrees, study at two well respected universities, collaborate internationally, and overall take part in a challenging program.

2.4 Case comparison

The three programs in this research all aim to prepare students from diverse backgrounds to become experts and leaders in sustainability through a combination of foundational instruction in sustainability concepts and praxis-oriented project work. The GSS program especially makes overlaps between the ASU and Leuphana sustainability Master's programs visible.

Curriculum comparison

The three Master's programs are similar in content requirements. All require classes on the fundamentals of sustainability science and research. All also offer and require courses which expand student knowledge and capacity in the natural and social sciences. They emphasize transdisciplinarity and also offer a wide array of electives for students to broaden their intellectual and disciplinary horizons. However, they differ in both build and approach.

ASU's rigid first semester format is intended to foster cohort cohesion and identity while building a uniform basis in sustainability. The Leuphana first semester offers more flexibility to encourage students to supplement their prior knowledge to build interdisciplinary competence. Part of the driver for this difference is university size. At ASU, students can choose from hundreds of electives across multiple campuses, and in those classes, they may be the only sustainability student. The sustainability cohort at Leuphana is much larger, and all courses the students will take throughout their studies will be with other sustainability students. Where ASU has one semester to build the students' identities as sustainability agents, the Leuphana students work in increasingly tight-knit groups throughout their studies.

The GSS students experience a mix of these approaches, with the Leuphana based students having somewhat more flexibility than the ASU based students. Changing campuses means all continuous collaboration will be within-cohort. However, this also makes building teamwork competencies and cohort identity early in the program importance for resilience.

Contextual differences and influence on curricular build and experience

The different contexts in which Leuphana and Arizona State University are situated influenced all levels of programs. ASU's larger size allows for a broader offering of classes, whereas Leuphana's size encouraged more within-faculty contact. Both universities created accredited programs, and both collaborated on the GSS. The program creation process at ASU involves a standardized set of tasks supported by a curriculum designer. The process at Leuphana was more task-meeting oriented. Like most German universities, Leuphana does not employ full-time curriculum designers. However, instructors at both institutions have the ultimate responsibility for course content.

Table 4: Comparison of the Leuphana, ASU, and GSS graduate sustainability programs

	Semester 1	Semester 2	Semester 3	Semester 4
Leuphana	*Sustainability Science 5CP*	Research methods 5CP	Research perspectives 5CP	*Master's Forum 5CP*
	Natural sciences 10CP	*Natural OR human sciences 10CP*	Natural OR human sciences 10 CP	
	Human sciences 10CP	Interdisciplinary methods 5CP	Ethics of science 5CP	*Thesis 25CP*
	Philosophy of science 5CP	Transdisciplinary research project 10CP	Transdisciplinary research project 10CP	
GSS Leuphana	*Sustainability Science 5CP*	Research Methods 5CP		*Master's Forum 5CP*
	Natural sciences 5CP	Sustainability Governance 5CP		
	Human sciences 5CP	*Natural OR human sciences 10CP*		*Thesis 25CP*
	Research methods 5CP			
	GSR1 GSR2	GSR3		
GSS ASU	*Sustainability perspectives 3Cr*		GSR4	*Synthesis for research 3Cr*
	Social-Ecological-Technical-Systems 3Cr		GSS Proposal and preparation 1Cr	*Research Paper 6Cr*
	Research Methods 3Cr			
	GSS perspectives 1Cr		*Electives 8Cr*	
ASU	*Sustainability perspectives 3Cr*	Normative elective 3Cr		*Synthesis for research 3Cr*
	Research methods 3Cr	Methods elective 3Cr	*General electives 6-9Cr*	*Thesis or Research Paper 6Cr*
	Social-Ecological-Technical Systems 3Cr	General elective 3Cr		
	Community of Scholars 1Cr	Community of Scholars 1Cr	Community of Scholars 1Cr	Community of Scholars 1Cr

Key: Cr = ASU credit system CP = European Transfer Credit System

Red Italicized = Courses with GSS overlap (ASU or Leuphana)

The difference in payment lead to differences in experience for the students. Funding became a barrier for several students. Students in the ASU M.A./M.S. all worked throughout their studies. They also applied for grants and/or additional scholarships to secure their funding and living expenses. One student was forced to interrupt their studies due to a loss of funding. This resulted in the student completing additional courses while simultaneously writing their thesis. Some of the students at Leuphana worked during their studies, but none faced termination of studies due to financial barriers.

Funding also proved to be a barrier to the GSS students. At ASU, low enrolment was the primary result. Three students from the M.A./M.S. program admitted that they would have preferred to enter the GSS program but were unable to secure funding. The necessary change of locations excludes GSS students from holding research or teaching assistant positions.

The GSS also faced additional contextual barriers due to location changes. The students themselves were tasked with organizing their travel, living, and visa arrangements. One student was unable to obtain a visa to study in the U.S., and subsequently dropped out of the program.

Such challenges do not directly influence curricula, but they do influence how students move through a program. ASU offers classes and workshops on finding grants and writing applications. Such a class would not be irrelevant Leuphana, but the students have less direct, urgent motivation to participate. Additionally, the funding pressure leads to inflexible perception of deadlines. The students at ASU and, by extension, the GSS students must complete their studies after four semesters or pay for an additional semester. For this reason, six of seven ASU students and all ten remaining GSS students completed their studies and graduated after the spring/Summer Semester in 2019. As of January 2020, none of the Leuphana students with whom the researcher is in contact had completed their thesis work.

Participants in research

General participation in research

This research includes input and experience from the students, instructors, supporting faculty, and project stakeholders involved in three graduate programs. All students in all three cohorts participated in this research, and they were in control of the extent of their participation. Focus groups were open to all students in the relevant program, and all students were also invited to contact the researcher formally or informally to discuss observations and experiences, which they did over the two years of this project. Instructors were also invited to participate in interviews and (with one exception) agreed. Similarly, curriculum designers, program coordinators, and pedagogical development experts involved in the programs were participants in the knowledge collection process. All participants were informed of the aim and scope of the project and gave their informed consent. The constellation of participants for each case differed due to institutional and pedagogical differences, and due to cohort size. The researchers took care to ensure that all ethical criteria for both Leuphana and ASU were met throughout the project.

Selection of long-term candidates

During the first required course of the semester the researcher introduced herself to all the students in the programs and distributed information materials about her project. This was facilitated by the offset semester schedules. All students were invited to participate in one-on-one interviews to get a general sense of the cohorts, student motivations, and to begin relationship building. Each student who elected to come to an interview was given more information about the longitudinal study and asked if they would be interested in participating. The students who answered affirmatively were noted. During this time, in-vivo observations of all required courses were ongoing, and the

researcher also attended social events and gatherings for each cohort in order to build familiarity. The researcher noted attendance habits of the potential candidates, class participation, and general attitude. This was to attempt to find students likely to participate in and complete their respective programs, and to get a sense of the candidates as people to facilitate a positive research relationship. Long-term candidates received verbal invitations after seven weeks of observations. If they assented, they were given extended consent forms outlining the research project in more detail. All students invited to participate accepted.

The pool of potential candidates was looked at based on potentially influential factors such as experience with project work, subject of their undergraduate degree (Remington-Doucette & Musgrove, 2015), stated program expectations, and apparent willingness to participate, i.e. whether they respond to e-mails and calls and their willingness to talk during interviews. Additionally, some students expressed specific interest in participation for reasons of diversity representation and voice giving. These students' wishes were respected. The research team elected to include students from the three main disciplinary backgrounds identified: natural sciences, social sciences, and business/economics. Three students were selected from the ASU M.A./M.S. cohort, and three students were selected from the Leuphana M.Sc. cohort. From the GSS, the ASU based student was selected along with four students from the Leuphana side. The fourth student was included due to participation in the Global Classroom, as it was determined necessary for transparency and diligence regarding the experience-based learning aspect of the research project. One of the selected GSS students left the study due to inability to continue with the program.

2.5 Outlook

This research focuses on multiple complex aspects of education. Key competence development, experience-based learning, and project-based learning are all community-embedded individual processes influenced by the individual students' own backgrounds, attitudes, and embodied knowledge (Kolb, 2015; Mezirow, 1997). By following multiple individuals from each program and comparing their experiences with the input from their cohorts, this research expects to find patterns relating experiences to competence. These patterns, embedded in the context of the curricula both as planned and as delivered, will result in insights on designing sustainability courses and programs that foster competence in future change agents.

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