Together for a Sustainable, Climate-Resilient, and Liveable Green Campus – Education for Sustainable Development (ESD) at the Hochschule Bonn Rhein-Sieg – A case study

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Abstract

This paper outlines the implementation of the interdisciplinary course "Green Campus: Together for a Sustainable, Climate-Resilient, and Livable University" with the objective of engaging students in developing ideas for a sustainable campus by building ESD competencies, such as active participation and reflective and critical thinking. It employed a problem-based learning approach to generate ideas on climate adaptation, waste management, and noise pollution. The framework for the course was based on the UN Sustainable Development Goals (SDGs), the climate adaptation strategy of the city of Sankt Augustin, and the sustainability strategy and infrastructure plans for a Green Campus at Hochschule Bonn Rhein-Sieg (H-BRS). To facilitate this, students conducted independent research in groups, used relevant crowd-sourcing apps and measuring devices, collected and mapped data, conducted interviews and surveys, and engaged with local stakeholders, including other students and representatives of the university's facility and sustainability management.

Keywords

sustainable development goals (SDGs); citizen science; problem-based learning; higher education

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1. Introduction

Education for Sustainable Development (ESD)[1] plays a key role in global efforts to achieve sustainability, as recognized by numerous international frameworks, especially those set forth by the United Nations (UN). Since the United Nations Conference on Environment and Development in 1992, ESD has been continually acknowledged for its key role in promoting sustainability. This focus on ESD has remained relevant, adapting to evolving global challenges and shaping educational approaches to sustainability.

The recognition of the critical role of education in sustainable development is reflected in key global frameworks. The United Nations 2030 Agenda for Sustainable Development, particularly through SDG 4, emphasizes Quality Education with a focus on Target 4.7, which promotes Education for Sustainable Development (ESD). Similarly, the UN Framework Convention on Climate Change (UNFCCC) highlights the importance of education in Article 6, titled "Education, Training, and Public Awareness," while the Convention on Biological Diversity (CBD) underscores the need for public education and awareness in Article 13 (UNESCO, 2014, pp. 10-11). These frameworks affirm that education is essential to achieving global sustainability goals and that knowledge and education are the foundation of a social-ecological transformation process that advances sustainable development.

This study is grounded in the Sustainable Development Goals (SDGs), which provide a global framework for addressing the interconnected dimensions of sustainability. However, recognizing the multifaceted nature of sustainability, the course design also integrated complementary conceptual models that inform educational practice in distinct ways. One such model is the Planetary Boundaries Framework (Rockström et al., 2009), which delineates the ecological limits within which humanity can safely operate. This framework emphasizes scientific literacy, systems thinking, and an understanding of biophysical thresholds as essential for guiding sustainable human action. In educational contexts, it supports the development of competencies in quantitative reasoning, ecological resilience, and Earth system science – encouraging learners to confront the planetary boundaries of sustainability directly.
In contrast, Raworth's Doughnut Economy (2017) extends the sustainability discourse by incorporating social justice and equity into ecological thinking. It presents a normative framework that challenges students to consider both environmental ceilings and social foundations in shaping a just and sustainable society. In educational settings, this model promotes value-based learning, ethical reflection, and critical engagement with issues of distributive justice and structural inequality. Together, these frameworks offer a holistic foundation for sustainability education, combining scientific understanding with normative inquiry.

The concept of *Gestaltungskompetenz* (shaping competence), is a central construct in the German discourse on Education for Sustainable Development (ESD) (de Haan, 2008). *Gestaltungskompetenz* refers to the ability to apply sustainability-related knowledge in real-world contexts, critically assess ongoing developments, anticipate future consequences, reflect on ethical implications, and co-design socially and ecologically viable solutions. This competency framework moves beyond the transmission of knowledge to emphasize transformative learning, agency, and the empowerment of learners as active participants in socio-ecological transformation processes.
The adoption of *Gestaltungskompetenz* aligns with international efforts to reorient higher education towards sustainability, as reflected in SDG Target 4.7 and UNESCO's ESD guidelines (UNESCO, 2014; Glavič, 2020). The framework incorporates a set of interrelated competencies – including systems thinking, anticipatory thinking, normative orientation, critical self-reflection, and collaborative action – that are particularly well-suited to address the complexity, interdependence, and uncertainty that characterize contemporary sustainability challenges.

To translate this competence model into pedagogical practice, the course employed a Problem-Based Learning (PBL) approach. PBL is a student-centered instructional method that emphasizes learning through the investigation of real-world problems. It

1 Education for Sustainable Development (ESD) is an educational approach that empowers individuals to make informed decisions and take personal and collective actions to foster social change and protect the planet. It provides and prepares people of all ages with the knowledge, skills, and values necessary to address critical issues such as climate change, biodiversity loss, resource overuse, and inequality (UNESCO, 2024).

fosters inquiry-driven, experiential learning, in which students are responsible for identifying knowledge gaps, engaging in iterative problem-solving, and working collaboratively across disciplinary boundaries (Krajcik & Blumenfeld, 2005; Steinemann, 2003; Thomas, 2009).

In the context of sustainability education, PBL offers particular advantages by promoting dialogical engagement, integrative thinking, and critical analysis. It cultivates key competencies – such as collaborative decision-making, critical reasoning, and adaptive problem-solving – that are essential for navigating complex socio-ecological systems (Brundiers & Wiek, 2010; Wiek et al., 2011). Moreover, PBL aligns with the broader aims of ESD by fostering learner agency, contextualized knowledge application, and reflective practice.

By integrating PBL with the concept of *Gestaltungskompetenz* and grounding the course in both scientific and normative sustainability frameworks, the instructional design supports the development of transferable competencies. These enable students not only to analyze sustainability issues on a conceptual level but also to engage with them practically, ethically, and collaboratively. This alignment of pedagogy, content, and competence development reflects a comprehensive approach to higher education for sustainable development.

Moreover, integrating cognitive tools, such as learning technologies, can significantly enhance learning effectiveness. These tools allow students to engage with complex sustainability problems in a more interactive and data-driven way. These technologies, providing access to various information sources, real-time data analysis, and data visualization, deepen students' understanding and enable more informed decision-making. This combination of collaborative learning and technological support strengthens the educational experience, allowing students to engage more comprehensively and dynamically with sustainability issues (Krakcik & Blumenfeld, 2005; Montiel et al., 2019; Rodríguez-Loinaz et al., 2022).

This paper explores the implementation of an interdisciplinary course titled "Green Campus: Together for a Sustainable, Climate-Resilient, and Livable University," which integrates the PBL approach within the context of ESD. We will examine the insights and outcomes from this course, offering a deeper understanding of effective learning strategies in sustainability education.

2. Context of the case study

The interdisciplinary course "Green Campus: Together for a Sustainable, Climate-Resilient, and Livable University" at H-BRS in Germany was developed for students enrolled in Business Administration and Sustainable Social Policy programs[2]. Offered in the third semester, the course aimed to provide students with practical insights into sustainability and climate resilience by addressing real-world challenges within the university campus context. By integrating theoretical frameworks with applied, hands-on learning experiences, students were encouraged to critically engage with sustainability concepts and explore potential solutions.

Although embedded within specific study programs, the course was intentionally designed to be interdisciplinary and inclusive of students without prior subject-specific expertise. Emphasizing collaborative learning, systems thinking, and participatory methods, the course enabled all participants to engage meaningfully with sustainability challenges. Its design fosters core competencies promoted by Education for Sustainable Development (ESD) and renders the format transferable to other academic disciplines, such as environmental sciences, engineering, or education, with only minor contextual adaptation.

The course builds upon the foundation established in earlier teaching formats launched in 2021, which addressed climate change challenges through citizen science and participatory methodologies. These earlier iterations were developed in collaboration with a diverse array of stakeholders, including local citizens, representatives from the City of Sankt Augustin, and the Bonn Science Shop (Wissenschaftsladen Bonn, WILA). This collaborative approach fos-

2 In German „Fachbereich".

tered active community engagement in addressing local sustainability and climate-related challenges.

3. Goals and didactical concept

The primary goal of the course was to foster key competencies related to Education for Sustainable Development (ESD), grounded in the concept of Gestaltungskompetenz (Shaping Competencies, de Haan, 2008). Students are engaged in a hands-on, interdisciplinary exploration of sustainability, using the H-BRS campus as a case study. This approach encouraged active participation, critical thinking, and practical problem-solving, while enhancing students' ability to apply sustainability concepts in real-world contexts.

To realize this didactic goal, the course employed a Problem-Based Learning (PBL) framework, enabling students to work collaboratively on authentic, locally relevant challenges. The course began with introductory lectures and stakeholder input sessions designed to provide foundational knowledge and real-world context. These sessions included the following:

- introduction to the United Nations Sustainable Development Goals (SDGs), with particular focus on SDG 4.7 (Education for Sustainable Development) and SDG 11 (Sustainable Cities and Communities)
- presentation of the H-BRS sustainability strategy, including current campus infrastructure plans and climate-related challenges
- overview of the City of Sankt Augustin's climate adaptation strategy, particularly regarding urban heat, green spaces, and biodiversity
- citizen science methodologies and their potential in academic and civic contexts
- discussions with experts from facility management and municipal administration on current sustainability measures, stakeholder roles, and institutional frameworks

While these sessions did not directly translate into applied action, they served as a crucial starting point for building students' action competence. By engaging with concrete examples of existing initiatives, students were able to understand not only what is being done, but also how sustainability work unfolds in institutional settings, including the actors involved, the constraints faced, and the types of knowledge and collaboration required.

The collaboration with university representatives and experts from the municipality of Sankt Augustin, Germany, provided essential thematic input that shaped the focus of the course. These stakeholder contributions laid the groundwork for students to engage in applied, interdisciplinary work, grounded in real-world challenges and institutional contexts. Based on consultations with these partners and the course instructors, three overarching themes were identified to reflect current sustainability challenges and strategic priorities of the campus: i) campus and waste, ii) campus and climate adaptation and iii) campus and noise.

While the overarching themes were defined at the outset by the teaching team and stakeholders to ensure institutional relevance, students were encouraged to critically engage with them and further refine their focus.

Following the introductory sessions, students were divided into small groups, each assigned to one of the three identified themes. Over the course of the semester, these groups worked independently to plan and carry out small-scale research projects. Their tasks included collecting and analyzing environmental data, conducting interviews with stakeholders, and critically evaluating existing sustainability measures on campus.

The use of crowdsourcing applications and measurement tools was central to the course design. These digital tools enabled students to combine scientific observation with participatory methods, building their digital and civic competencies while engaging with complex sustainability issues in an evidence-based and interactive manner. Each thematic group approached their topic through a combination of

technical data gathering, stakeholder engagement, and critical reflection.

1. **Campus and Waste:** Students examined the university's waste management practices, identifying opportunities to reduce waste generation, enhancing recycling processes, and promoting circular economy principles. Students conducted a critical assessment of the university's waste management system, aiming to identify inefficiencies and opportunities for more sustainable practices. As part of their investigation, they utilized the Dreckspotz app, a citizen science tool that enables users to geolocate and report litter and pollution incidents in public spaces. By systematically mapping waste hotspots across the campus, students were able to visualize problem areas and analyze spatial patterns of improper disposal. To complement the digital mapping, students carried out informal interviews with other fellow students, to gain insights related to waste separation and recycling practices. This qualitative data helped contextualize the observed issues and informed their interpretation of the collected data.
2. **Campus and Climate Adaptation:** This group focused on identifying climate vulnerabilities on campus, particularly those related to heat exposure and lack of shading. Using the KlimNet platform, a web-based CrowdMapping tool for documenting local climate change impacts and adaptation actions, students submitted geolocated observations of heat-prone areas, sealed surfaces, and existing greenery. They also used thermo-hygrometers to measure temperature and humidity in different microclimates around the campus.
3. **Campus and Noise:** Given the increasing significance of noise pollution in urban environments, students investigated noise sources on campus and explored strategies for noise reduction to enhance the well-being of students and staff. In this context, noise pollution referred to unwanted or disruptive sound levels in spaces intended for learning, working, or resting, such as near lecture halls, common areas, or outdoor seating zones. To assess this, students employed quantitative and qualitative methods. They used sound level meters to measure decibel levels at different times of day and in various locations across the campus. These measurements were then analyzed against reference values for acceptable ambient noise in learning and recreational environments. In addition to these technical readings, students also worked with the Hush City app, a citizen science tool that allows users to identify, rate, and comment on quiet or noisy areas in their surroundings.

The course design integrated a combination of introductory lectures, stakeholder dialogues, student-led group work, and scheduled office hours (available both in-person and online). This multimodal structure fostered a dynamic learning environment that encouraged both autonomous exploration and collaborative knowledge creation. Students were guided in developing context-specific, actionable sustainability proposals, which were subsequently presented to relevant stakeholders from the university and local municipality.

Over the course of the semester, the instructional team held three scheduled office hour sessions, providing students with the opportunity to discuss their project progress, pose questions, and receive formative feedback. Although participation in these sessions was voluntary and generally limited, each student group ensured consistent representation often by rotating attendance among members.

3.1 Core competencies (Gestaltungskompetenzen) developed

The course focused on developing the following core competencies:

1. **Engagement in Sustainability Processes:** Students were encouraged to actively participate in sustainability initiatives on the H-BRS campus, exploring methods to support and enhance campus-based sustainability efforts.
2. **Identification of key actions and stakeholders in Campus sustainability:** A component of the course involved analyzing the critical actions, stakeholders, and institutional structures that shape

sustainability practices on campus. This process deepened students' understanding of how sustainability is integrated into campus operations and activities.

3. **Interdisciplinary collaboration:** Through group discussions and collaborative work, students explored various models of cooperation essential for creating a more sustainable campus. This included evaluating interdisciplinary partnerships and engaging with key university stakeholders to develop integrated solutions that reflect diverse perspectives and expertise needed to address complex sustainability challenges.
4. **Developing Campus strategies for sustainability and well-being:** The course emphasized identifying and developing actionable strategies to enhance sustainability, climate resilience, and overall well-being on campus. Students assessed specific campus challenges, such as waste management, climate adaptation, and noise pollution, and proposed practical improvement solutions.
5. **Digital competencies and crowdsourcing applications:** The course's innovative aspect was its focus on building digital competencies through the use of crowdsourcing applications. Students were introduced to various digital tools and measurement devices to collect and analyze sustainability-related data. This approach enhanced students' digital literacy and allowed them to integrate emerging technologies into their sustainability projects.

Collaboration was a central theme throughout the course. By utilizing crowdsourcing applications, data collection tools, surveys, interviews, and presentations, students worked together to address sustainability challenges on campus. These collaborative activities enabled students to gather valuable data, identify trends, and generate evidence-based solutions for sustainable campus development.

4. Outcomes and conclusion

The course adopted a multifaceted approach to learning, combining in-person lectures, collaborative teamwork, and student-led discussions. Lecturers and external experts from the university administration and the local municipality provided insights into campus sustainability, climate resilience, and environmental stewardship. These expert presentations were complemented by interactive sessions, encouraging students to engage directly with the material and collaborate.

Fifteen students participated regularly in the course, actively engaging in group activities and individual presentations. The collaborative component of the course enabled students to apply their theoretical knowledge to real-world sustainability challenges faced by university campuses. Working together, students analyzed key environmental impacts of campus operations, developed strategies for enhancing climate resilience, and proposed solutions to create a more sustainable and livable campus environment. On the topic of waste, students identified several litter hotspots using the Dreckspotz app and found inconsistencies in bin placement and labeling. They proposed the introduction of multilingual and color-coded signage, strategic relocation of recycling stations, and a campus-wide awareness campaign focused on circular economy principles. A notable challenge here was the communication gap between facility services and students, which limited shared responsibility for waste management. Students recognized the need for better feedback loops and co-created communication tools to bridge this divide.
For climate adaptation, students used spatial data from KlimNet and temperature measurements to map heat-prone areas, particularly around sealed surfaces and unshaded walkways. Their proposals included installing shaded seating areas, adding green roofs, and increasing tree cover in outdoor communal spaces. A challenge in this context was balancing ecological ideas with practical feasibility, including cost, maintenance responsibilities, and integration with existing infrastructure. Students reported gaining a deeper understanding of how urban microclimates function and how adaptive measures require negotiation among multiple stakeholders.

In the noise group, students conducted decibel measurements and used the Hush City app to assess both objective and subjective perceptions of noise on campus. They identified high-exposure zones, such as courtyards and corridors near lecture halls, and recommended the designation of quiet zones, acoustic landscaping with hedges and trees, and sound-absorbing materials in high-traffic areas.
While the student proposals were not implemented directly, they were well received by university administrators, who expressed interest in integrating several suggestions, including shaded seating, multilingual signage, and quiet zones – into future planning. Although no binding commitments were made, these outcomes stimulated internal discussions and demonstrated the potential of student-driven initiatives to inform campus sustainability efforts.
Students demonstrated enhanced action competence, evident in their ability to diagnose campus-specific sustainability challenges, collect and analyze data, and develop implementable solutions that were well-received by university and municipal stakeholders. Particularly successful were the use of digital citizen science tools, the grounding of topics in real institutional needs, and the balance between theoretical orientation and practical group work.

In conclusion, the interdisciplinary and practice-oriented design of the course enabled students to acquire a robust set of transferable skills, preparing them to address sustainability challenges both within academic settings and in their future professional roles. Through the development of evidence-based proposals, including improved waste signage, climate-adaptive infrastructure and quiet zones, students applied participatory methods and digital tools to diagnose real-world problems and suggest context-sensitive solutions. While the proposals were not implemented directly, they were well received by university stakeholders and have sparked further institutional reflection. By centering the course on ESD competencies and the concept of *Gestaltungskompetenz*, the learning experience fostered critical thinking, stakeholder engagement, and collaborative problem-solving – core competencies for driving sustainability transformations in diverse contexts.

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