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Bridging Disciplines in Higher Education: The Convergence of AI and Sustainability

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Abstract
The 'digitalization lab sustAInability' represents an educational initiative, bridging the realms of artificial intelligence (AI) and sustainability within an interdisciplinary, cross-university framework developed collaboratively by experts in computer science, political, social and economic sciences. The primary learning objective is to weave AI into the three dimensions of sustainable development – economy, society, and ecology – fostering a trans- and interdisciplinary understanding. This paper introduces a pioneering educational framework, focusing on how this course equips students as key architects of a sustainable future. Emphasizing the need for future competencies in sustainability of AI and AI for sustainability, the program not only educates but also acts as a platform for these critical issues across the involved universities and beyond. This program cultivates students who are equipped to handle the complex interplay between technology and sustainability in their future professional roles, contributing to societal, economic, and environmental advancement.

Keywords: *AI and sustainability; interdisciplinary course; cross-university learning; higher education; challenged-based teaching; future skills development.*

1. Introduction

The past decade marked an era of unprecedented growth in artificial intelligence (AI). Today, AI is profoundly influencing diverse sectors including business, industry, and research. The surge in computational power, the abundance of data, and significant algorithmic advancements have propelled machine learning (ML) – particularly deep neural networks – to the forefront of innovation. However, AI's duality in the context of the Sustainable Development Goals (SDGs) presents a tension of extraordinary promise tempered by considerable risks. While AI-driven technologies promise vast opportunities for sustainable progress in areas such as energy or agriculture, they also bring environmental and societal challenges (Vinuesa et al., 2020;

Coeckelbergh, 2021). These include substantial energy demands and carbon emissions of training and using ML models, alongside concerns of algorithmic bias and discrimination. This dichotomy underscores the need for a nuanced understanding of AI's role in shaping a sustainable future. We agree with (Crawford & Calo, 2016) on the sentiment that AI presents a cultural shift as much as a technical one. Therefore, the urgency to bridge the gap between technological advancements and sustainability in an interdisciplinary and culturally diverse environment has never been more critical.

In a joint project between the Hochschule München University of Applied Sciences and the Technical University of Munich, the teaching and research course sustAInability – Advanced Topics on Sustainability and AI studies the opportunities and interdependence, and – together with an interdisciplinary group of students – develops technical and non-technical solution approaches at the intersection of AI and sustainability. Our course aims to transcend traditional academic boundaries, fostering a holistic understanding of AI's potential to drive sustainable solutions. By blending theoretical knowledge with practical applications, it prepares students to innovate responsibly, ensuring that technological development aligns with ecological and societal well-being. We belief that the introduction of an interdisciplinary course, integrating AI with sustainability practices, marks a pivotal shift towards nurturing a generation equipped to tackle the pressing challenges of our time.

This paper delves into the genesis of this innovative educational model, highlighting its objectives, design, and the imperative for such interdisciplinary approaches in cultivating future leaders capable of navigating the complexities of a rapidly changing world.

2. Objectives and Rationale

The interdisciplinary course sustAInability – Advanced Topics on Sustainability and AI aims to forge a new pathway in higher education by integrating the dynamic field of AI with the multifaceted concept of sustainability. The course is designed to equip students with the necessary skills and knowledge to become influential actors in shaping a sustainable future using AI and assessing potential benefits and risks with respect to contributing to the SGDs. The rationale for this challenge-based course stems from the significant advancements in AI over the past decade, which have brought both transformative potential and profound challenges to society. As AI applications increasingly permeate our daily lives, the need for a critical understanding of their impact on sustainability becomes paramount. Our course aims to address this need by intertwining AI with the three pillars of sustainable development: economic, social and environmental.

It focuses on both sides of Sustainable AI (van Wynsberghe, 2021), that is, AI for sustainability and the sustainability of AI. The goal is to educate students on how AI can be leveraged to foster sustainable development across various sectors, including but not limited to energy, agriculture, and social governance. Furthermore, students learn how to critically examine the sustainability of AI systems themselves, considering possible tensions with all three pillars of sustainability with respect to the whole AI life cycle.

A central feature of the course is its project-oriented learning approach, which encourages students to apply theoretical knowledge to practical real-world challenges. This method aims to foster critical thinking, problem-solving skills, and the ability to work collaboratively across disciplines (Bell, 2010). Through this approach, students will be prepared to contribute meaningfully to sustainable solutions in their professional endeavors (Blumenfeld et al., 1991).

By integrating disciplines, the course prepares students to critically assess and navigate the complexities of AI in the context of global sustainability challenges. Graduates of this program are expected to emerge as leaders who can balance technological innovation with sustainable practices, contributing to the achievement of the Sustainable Development Goals (SDGs). The course, therefore, sets out to create a platform for sustainable AI education and to catalyze interdisciplinary dialogue and collaboration across the academic community and beyond.

3. Course Design

Our interdisciplinary course is designed to provide an integrative learning experience that spans across a semester, offering students the opportunity to earn 6 ECTS[1] credits through a blend of self-study, seminar participation, and a collaborative project week. The course commences with a kick-off event that provides students with an initial substantive insight into the focal topics as well as an overview of the structure and sequence of the program. Leveraging speculative design methodologies (Auger, 2013), a futurizing workshop is conducted, enabling students to envision future scenarios and grasp the ethical, technological, ecological, social, and economic implications of AI.

Until week 9, the course focuses on building a foundational understanding and facilitating critical engagement with the dual perspectives of sustainability and AI. It proceeds with an introductory teaching-learning unit (Unit 1), setting the stage for exploring how AI can be harnessed for enhanced sustainability and what constitutes sustainable AI practices. Subsequent units are bifurcated into two tracks, allowing students to delve into the benefits of AI for each sustainability dimension (environmental, economic, and social) while concurrently critiquing AI technologies from a sustainability point of view. Each unit features a two-week self-learning phase culminating in a four-hour seminar, where students independently investigate specific themes and then collaboratively discuss identified questions and problems using the just-in-time teaching approach (Novak et al., 1999). With useful facts and references to further literature,

[1] ECTS: European Credit Transfer System

those topics are supplemented by the instructors. The collection of topics, issues, and extended content thus provides the foundation for the project work in the subsequent workshop week. The respective modules employ various teaching and learning formats and methods aimed at the acquisition of diverse competences (see Figure 1) motivated by the key competencies in sustainability (Brundiers et al., 2020; Wiek et al., 2011).

Week 1	Week 2	Week 3 & 4	Week 5 & 6	Week 7 & 8	Week 9	Week 10
Seminar	Seminar	Self-study & seminar	Self-study & seminar	Self-study & seminar	Self-study	Interactive workshop
Kick-off Check-In, course overview workshop: futurizing	**Unit 1: Introduction** AI for sustainability & sustainablilty of AI	**Unit 2: AI & Ecology** Track A: AI for the environment, Track B: ecological AI	**Unit 3: AI & Economy** Track A: AI for a sustainable economy, Track B: AI and economic sustainability	**Unit 4: AI & Social Justice** Track A: AI for social justice Track B: AI for the common good	**Reflection** Pooling of ideas, collecting and rehashing of results from Unit 2-4	**Workshoopweek** Development of technical and non-technical solutions to challenges in the context of AI and sustainability.
Aquired 21st Century Skills						
Analytical thining	Analytical thining	Analytical thining	Analytical thining	Analytical thining	Sense making	Design mindset
Critical thinking	Critical thinking	Critical thinking	Critical thinking	Critical thinking	Digital literacy	Computational thinking
Interdisciplinary work	Computational thinking	Computational thinking	Computational thinking	Computational thinking	Tolerance of ambivalence	Noval & adaptive thinking
		Independent work	Independent work	Independent work	Virtual and personal communication & collaburation	Creative problem solving

Figure 1. Structure of the digitalization lab sustAInability.

The final week encapsulates the essence of the course, where students engage in a workshop week, applying their accrued knowledge to conceive and develop creative solutions to pre-identified real-world challenges. This last phase is dedicated to project work that synthesizes theoretical insights with practical applications, prompting students to translate academic concepts into concrete, innovative, and practice-oriented proposals.

Interdisciplinarity is woven throughout the course structure, merging social sciences with technical and economic disciplines. Partner institutions contribute expertise in computer science, economics, entrepreneurship, political science, and sustainability governance, creating a multi-perspective platform for innovation. The co-teaching strategy enriches content delivery, ensuring a comprehensive understanding of the complex interplay between AI and sustainability. The pedagogical design emphasizes project-oriented work and interdisciplinary teams, enhancing outcome quality by utilizing diverse student skill sets. This approach fosters cross-disciplinary cooperation and prepares students to apply their knowledge in ways that are reflective, informed, and sensitive to the various dimensions of sustainability and technological impacts.

In summary, the sustAInability course is a comprehensive educational endeavor that integrates self-directed learning, interactive seminars, and collaborative project work, all underpinned by the critical and innovative exploration of AI and sustainability. Its design reflects a commitment to developing competencies that are essential for addressing the challenges and opportunities at the intersection of these pivotal fields. The course acknowledges that the challenges and opportunities presented by AI and sustainability are too complex to be addressed from a single disciplinary perspective. Instead, the course prepares students to become adept at navigating and integrating multiple fields of study, fostering a breed of professionals who can contribute to sustainable development with technological acumen and a comprehensive worldview.

4. Expected Outcomes and Impact

The course is designed on the assumption that acquiring skills in the 21st century requires digital and technological skills. At the same time, these skills must be considered in the context of ecological, social and economic changes. Digital and technological skills alone are not sufficient to prepare students for the major challenges of the coming decades, so the interdisciplinary approach of the college aims to combine education for sustainable development (ESD) with digital and technological skills. The skills acquired through the program include:

1. **Professional competence**. Students can reproduce subject-specific knowledge on concepts and developments in the field of ecological, economic and social sustainability and AI, name advantages and disadvantages and illustrate them using examples. They can interpret and compare current developments and interdisciplinary perspectives on the intertwining of sustainability and AI. Students can assess the impact of AI on different dimensions of sustainability.
2. **Methodological competence**. Students can apply interdisciplinary methods to analyze, develop and reflect on concepts at the interface of sustainability and AI. They can develop use cases for AI in sustainability and develop concrete approaches on how AI can be used to solve sustainability challenges or how AI can be made more sustainable.
3. **Self-competence**. Students can locate their own role in the digital and sustainable transformation, position themselves and develop further within these transformations.
4. **Social competence**. Students can communicate efficiently and productively with other disciplines and initiate and implement collaborative projects.

The course aims to influence the students' educational journey significantly, guiding their choices for thesis topics and early career steps, including the uptake of internships or student jobs with a focus on AI and sustainability. Additionally, the partners involved in the program contribute a broad network from both the Munich and Bavarian ecosystems, thereby creating a supportive environment for project development and potential scale-up.

5. Evaluation

In an initial pilot study, we administered a questionnaire to participants, with 20 out of the 32 completing a self-assessment. The questions are listed in Table 1. The questionnaire utilized a

Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) for responses. In addition, participants were asked three free-text questions: Q1, Q8, and Q10.

Table 1. Mapping between the question's abbreviations and its content.

Abbr.	Question
Q1	What was your initial motivation to participate in this course? Please explain.
Q2	Participating in the course has enhanced my knowledge and skills about sustainability of AI.
Q3	Participating in the course has enhanced my knowledge and skills about AI for sustainability.
Q4	I want to continue developing my knowledge and skills about AI applications for the Sustainable Development Goals (SGDs) after this course (additional classes, project continuation after the course, career orientation, etc.)
Q5	I feel capable of applying AI concepts and techniques to impact the Sustainable Development Goals (SGDs).
Q6	What would have been your answer to the previous question before the course?
Q7	I benefited from the interdisciplinary nature of the project workshop course.
Q8	Please explain your previous answer.
Q9	The challenge-based format of the course specifically helped me to develop my knowledge and skills about sustainability and AI.
Q10	Please explain your previous answer.
Q11	I am able to assess how an AI contributes and hinders the Sustainability Development Goals (SGDs).

The data, visualized in Figure 2, suggest that participants perceive an enhancement in their knowledge of both the sustainability of AI (Q2) and AI for sustainability (Q3). The majority express continued interest in the field (Q4). Additionally, respondents report increased competency in applying their knowledge (Q5-Q6) and in evaluating potential challenges and advantages related to achieving the Sustainable Development Goals (SDGs) (Q11). The feedback also reflects a positive reception of the interdisciplinary and challenge-based structure of the course (Q7-Q10). The rationale behind the students' motivation for the course (Q1) indicates the perceived importance of AI for their future careers. Four students explicitly emphasized their interest mainly in sustainability. Seven emphasized AI as the driver to join the course and eight mention sustainability as well as AI.

Sustainable AI is a field marked by tension that consists of a seemingly inexhaustible body of knowledge. Finding the balance between depth and breadth has been, and continues to be, a major challenge in the design of our course. Therefore, it is no surprise that the only criticism we received from two participants is a lack of depth. To enhance depth, we plan to carefully integrate a greater number of curated case studies and a well-structured literature collection.

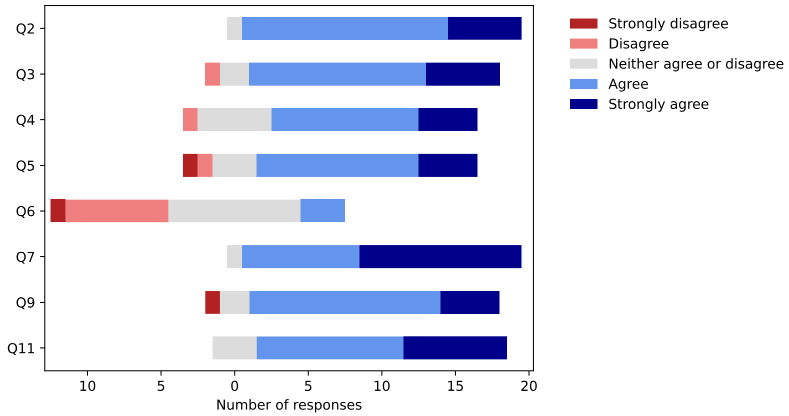

Figure 2. Result of the questionnaire. The difference between Q5 and Q6 indicate a shift in the students' confidence to be able to apply AI concepts and techniques to impact the SGDs.

6. Conclusion and Future Work

Through the digitalization lab sustAInability – Advanced Topics on Sustainability and AI, we were able to specifically promote sustainable AI competencies of the students and to open a new horizon. A solid foundation has been laid, which is still capable of further development – the necessity for additional specialized courses is evident. We belief that our students have acquired the necessary competencies to independently explore this horizon further, to communicate about sustainability issues effectively and to be able to assess benefits and risks of specific AI applications. This belief is bolstered by the results of our pilot study. However, for a solid analysis we require additional results from upcoming semester, including a pre- and post-questionnaire.

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