2023-10-10

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Recommended Citation

Schleiss, J., Manukjan, A., Bieber, M. I., Pohlenz, P., & Stober, S. (2023). Curriculum Workshops As A Method Of Interdisciplinary Curriculum Development: A Case Study For Artificial Intelligence In Engineering. European Society for Engineering Education (SEFI). DOI: 10.21427/XTAE-AS48

CURRICULUM WORKSHOP AS METHOD OF INTERDISCIPLINARY CURRICULUM DEVELOPMENT: A CASE STUDY OF ARTIFICIAL INTELLIGENCE IN ENGINEERING

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Conference Key Areas: *Curriculum Development, Education about and with AI*
Keywords: *Engineering Curriculum, Curriculum Development, AI Education*

ABSTRACT

The integration of tools and methods of Artificial Intelligence (AI) into the engineering domain has become increasingly important, and with it comes a shift in required competencies. As a result, engineering education should now incorporate AI

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competencies into its courses and curricula. While interdisciplinary education at a subject level has already been explored, the development of interdisciplinary curricula often presents a challenge. This paper investigates the use of the curriculum workshop method for developing interdisciplinary, competence-oriented curricula. Using a case study of a newly developed interdisciplinary Bachelor program for AI in Engineering, the study evaluates the instrument of the curriculum workshop. The communicative methods of the tool and various aspects of its implementation through self-evaluation procedures and surveys of workshop participants are discussed. The results show that the structure and competence orientation of the method facilitate alignment among participants from different disciplinary backgrounds. However, it is also important to consolidate the mutually developed broad ideas for the curriculum design into concrete outcomes, such as a competence profile. Interdisciplinary curriculum development needs to take into account different perspectives and demands towards the curriculum which increases complexity and requires a more structured design process. The findings of the paper highlight the importance of interdisciplinary curriculum design in engineering education and provide practical insights in the application of tools for the creation of competence-oriented curricula in curriculum workshops, thereby contributing to the development of future engineers.

1 INTRODUCTION

The application of Artificial Intelligence (AI) as a tool becomes more and more relevant in the engineering domain. This shift also results in new demands from the market towards the education of future engineers and highlights the importance of interdisciplinary approaches (Gumaelius and Kolmos 2019). From an engineering education standpoint, the advancement of the application of AI in the engineering field requires transforming study programs and the respective curricula to incorporate these new competence requirements while at the same time addressing the specific context of the engineering domain (How and Hung 2019; Schleiss et al. 2022). Thus, interdisciplinary engineering education approaches and close collaboration between different disciplines are essential.

In the context of this paper, we refer to a curriculum as the decision of what students should learn and the collection of subjects offered to address this particular learning goal. Hence, curricula are more than a compilation of stand-alone subjects, but design an overarching framework for the development of an academically trained personality. Here, interdisciplinary curricula are often expected to address knowledge and skills that address students' real-world problem-solving competencies (van den Beemt et al. 2020).

At the same time, designing interdisciplinary curricula is a complex task and comes with several challenges. One challenge is determining the sequence in which the students learn content, either going deeper in a single discipline or understanding the breadth of the field first (Bächthold 2013). Moreover, designing interdisciplinary curricula requires finding an agreement between different discipline cultures,

experiences, and interests (Millar 2020). It requires finding a common ground and mutual understanding. Overall, interdisciplinary curriculum development is a difficult task but can be key for bringing new perspectives and competencies to engineering education (van den Beemt et al. 2020).

In this paper, we focus on the question on how well the curriculum workshop method is suited for the development of interdisciplinary curricula at the intersection of AI and engineering with regard to interdisciplinarity, cooperation, participation, and composition. Moreover, we investigate key considerations in implementing the curriculum workshop method in an interdisciplinary setting. We analyze the use of curriculum workshops in the development of a novel bachelor program at the intersection of AI and engineering as a case study. Overall, our study contributes to an improved understanding of the process and considerations in interdisciplinary curricula development and the use of the curricula workshop method in an interdisciplinary setting.

2 RELATED WORK

2.1 Interdisciplinary Engineering Education

Interdisciplinary engineering education builds on the idea to bridge the different epistemologies of disciplines and to integrate content and concepts from different disciplines into one teaching approach (van den Beemt et al. 2020; Lindvig and Ulriksen 2019; Spelt et al. 2009). It is often built with the vision to develop competencies for complex real-world situations, such as collaboration or communication (van den Beemt et al. 2020; Lindvig and Ulriksen 2019; Lattuca et al. 2017) and in return, increase the employability of future engineers (Gumaelius and Kolmos 2019). Moreover, interdisciplinary teaching should improve disciplinary programs and the students' motivations (van den Beemt et al. 2020; Lindvig and Ulriksen 2019).

Research on interdisciplinary curriculum design indicates that interdisciplinary knowledge is less clearly classified as compared to discipline-based knowledge (Millar 2015), which Millar (2016) and Muller (2016) link to a limited depth of knowledge that students encounter in interdisciplinary curricula. This indicates that interdisciplinary curriculum development needs a careful balance between width and breadth (Bächtold 2013; Blizzard et al. 2012).

2.2 Curriculum Development Approaches

A structured, competence-oriented, and student-centered development of study programs can be approached from multiple perspectives. Although there are different approaches to curricula development (Schaper et al. 2012; Kern 2016; O'Neil 2015, Gotzen et al. 2018), they share similar characteristics. The design of the curriculum usually starts with an analysis of the context in which the curriculum is embedded. Next, learning objectives and outcomes are defined and appropriate teaching methods are selected. Then, the curriculum is implemented and evaluated to ensure, that the set goals are achieved. Curriculum development, therefore

represents an iterative, ongoing and reflexive process aimed at continuous improvement and adaptation of the curriculum.

Schaper et al. (2012) presented basic principles of competence-oriented curriculum development, introducing various possibilities of programme and curriculum development, which refer to both, a theoretically based approach from the academic domain and a practice-guided approach. According to the authors, there are three different ways to curriculum development. First, the use of already existing mission statements and training standards or competence profiles. Second, surveying graduates of comparable study programmes and subject-specific employers and third, participatory methods for the development of novel and non-comparable degree programmes.

Here, the case study of AI in engineering targets a novel curricula development which has no existing references of competence profiles or existing programmes. This interdisciplinary setting at the intersection of AI and engineering involves participants from multiple domains, with different experiences and broad demands on the curricula. Thus, a participatory approach is chosen to foster the discussion and alignment between all stakeholders.

2.3 Artificial Intelligence Education in Engineering

AI is becoming increasingly relevant in engineering education (Gumaelius and Kolmos 2019). Schleiss et al. (2022) proposed an interdisciplinary competence profile for AI in Engineering, highlighting the need for interdisciplinary access that includes interdisciplinary communication skills and methodological skills along with solid professional competencies in AI and the domain.

AI education itself is often discussed in an interdisciplinary setting due to its roots in the fields of philosophy, neuroscience, psychology, cognitive science, and math (Mishra and Siy 2020). Janssen et al. (2020) reported, for example, on experiences of an interdisciplinary AI master program. Their curriculum is built around six core characteristics: (1) courses are taught by multidisciplinary and interdisciplinary staff, (2) engineering techniques and theory are used hand-in-hand, connecting implementation to theoretical concepts, (3) students are given choices in assessment and presentations to allow for individual interests, (4) highlighting relevance to practice and industry, (5) highlight multidisciplinary origins of machine learning, and (6) balancing skill levels. Similarly, Ng et al. (2022) argued that AI literacy should not be seen as specialized field under engineering but should be seen as a competence for students from all disciplines and levels. Moreover, How and Hung (2019) suggested that AI education for STEAM education differs from Computer Science AI education.

Working with AI can also have ethical, legal, and social implications. Thus, ethics education needs to be integrated into AI education to foster the understanding and discussion of ethical, social, and legal implications of the application of AI (Borenstein and Howard 2021; Furey and Martin 2019). This can include, for example, developing an understanding of bias, fairness, explainability, privacy, trust,

and transparency. Overall, this highlights the complex needs and requirements to integrate multiple perspectives into an interdisciplinary curriculum for AI in Engineering.

3 CASE STUDY: INTERDISCIPLINARY CURRICULUM DEVELOPMENT FOR A BACHELOR PROGRAM AI ENGINEERING

3.1 Methodology

The study employs a design-based research approach (Anderson and Shattuck 2012). The curriculum workshop, which refers to a series of workshop sessions with all involved stakeholders from the participating disciplines, was developed based on existing approaches for the development of study programs from literature (Section 2.3). This theoretical artifact was tested in practice with a case study of a curriculum workshop series for an interdisciplinary bachelor program at the intersection of AI and engineering. The case study is analyzed through self-evaluation procedures of the facilitators (authors) and quantitative ex-post surveys with the participants at the end of the workshop series.

3.2 Methodological Approach of the Curriculum Workshop Series

The curriculum workshop addressed in this paper was conducted in three phases, which were run through several workshop sessions (Fig. 1). The first phase covered the problem identification and a general needs analysis. The aim was to create a common starting point for the development of the curriculum. The second phase aimed to develop a coherent competence profile of the overall program. The competence profile built the foundation of competencies the graduate will have upon completion of the program. The third phase aimed at developing a module matrix and the lecture design.

Fig. 1: Three phases of the curriculum workshop method

3.3 Implementation

The bachelor program of the investigated case study is a collaboration between five higher education institutions. Therefore, the development process was conducted in online workshops. Overall, ten curriculum workshops were held in the process of development between February 2022 and July 2022. The participants were part of the development process and were delegated by the participating universities. The composition of participants changed in part.

Each workshop session was conducted by two facilitators and supported by an impulse presentation. After an introduction to the content and a short update of for participants, the workshop focused on co-creation in smaller sub-groups on the respective topics. Participants worked on a visual collaboration platform, allowing synchronous work and compiling of results. At the end of each session, the results were brought together into the plenum. Following each workshop session, the results

produced through group or individual work were categorized, sorted, and further edited in such a way that, if possible, a new artifact of the development process emerged.

3.4 Interdisciplinarity in the Development

Interdisciplinarity in this context describes both a collaboration of the disciplines between engineering sciences and AI, as well as between the different engineering disciplines. To practice participative co-creation, it was aimed to ensure that at least one representative from each institution and each subject area could participate in each session. At the same time, participants could freely choose to participate based on their availability, leading to an unbalanced number between institutions or disciplines in some workshop sessions. In the development of the competence profile and the module matrix, a concentration of expertise was achieved through small group work according to subject affiliation, which was then brought together and discussed in the large group. The mixing and discussion led to an exchange between the disciplines.

3.5 Evaluation

The effectiveness of the approach was assessed using both self-evaluation procedures with the facilitators and quantitative ex-post surveys among the participants after completion of the workshop series.

The ex-post evaluation focused on key areas such as the implementation and methodology of the curriculum workshops, as well as the level of specificity and successful implementation of interdisciplinary curriculum development within the workshops. For the survey, all those who had participated in at least one session were contacted and reminded twice; this applied to 30 people. Of these, 14 took part in the survey. The data was analyzed using IBM SPSS Statistics. The closed-ended items of the survey were reported indicating the extreme values.

4 RESULTS

4.1 Self-Evaluation of Facilitators

The experience of the workshop facilitators indicates that it is important to keep the session format flexible, to plan in sufficient time buffers to integrate many different perspectives, and to give everyone the space to contribute their perspectives. In contrast to one thematic focus, it is important to run through content goals several times in order to absorb interdisciplinarity. In addition, intensive preparation and follow-up as well as the formulation of clear work assignments are essential to involve all participants in the process. This was particularly important since the participants changed between the individual curriculum workshops. The online format proved to be very profitable and made it possible to bring together the different interest groups in a digital space despite the physical distance.

4.2 Ex-post Evaluation of Participants

These experiences can also be confirmed by the ex-post evaluation. The majority of the fourteen participants was academic staff, and three of whom stated that they were professors. Half said they belonged to the computer science domain, and the other half assigned themselves to the engineering domain. The evaluation of the curriculum workshop was carried out concerning the implementation, the method as well as the topic of interdisciplinarity.

Implementation of the curriculum workshops The implementation of the curriculum workshop sessions was surveyed through eight individual items using a 5-point Likert scale (1 "do not agree at all" to 5 "agree completely"). Overall, the implementation was evaluated very positively by the majority of the 14 respondents (agreement by 10 or more of the respondents on good preparation, use of tools was helpful, appropriate duration).

Method of the curriculum workshops Respondents were also asked to rate eight individual items regarding the methods of the curriculum workshop. The majority of respondents (12 out of 13) agreed that the curriculum workshop sessions were helpful in exchanging ideas and perceptions and that it was a participatory method (scores of 4 and 5 on a scale of 1 "do not agree at all" to 5 "agree completely"). Only six of the 13 respondents, however, agreed with the statement "The curriculum workshop method was helpful in working out formulations." (4 and 5 on the scale).

Interdisciplinary Cooperation and Participation Almost three-quarters of the respondents (9 out of 13) agree with the statement that the curriculum workshop is a suitable tool for taking interdisciplinary perspectives into account. The majority of respondents agreed with the statements "I was able to work productively with representatives of other subjects and/or subject cultures" (11 out of 13 respondents), "I consider the interdisciplinary cooperation to be profitable overall" (12 out of 13 respondents) and "Difficulties in understanding between subjects and/or subject cultures were addressed by the moderation" (11 out of 13 respondents) (in each case values 4 and 5 on a scale from 1 "do not agree at all" to 5 "agree completely"). Participants partly reported problems with interdisciplinary cooperation in the workshops, but the frequency of the problems was estimated by most only as occasional (see Fig. 2).

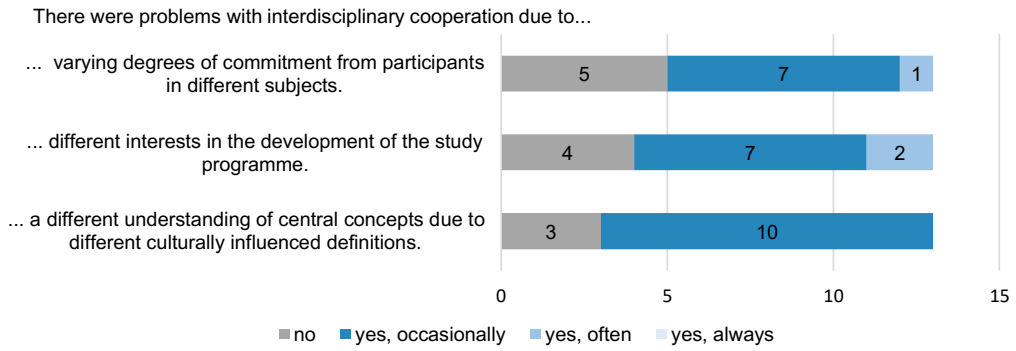

Fig. 2: Problems with interdisciplinary cooperation within curriculum workshop sessions (absolute frequencies; n=13)

Overall Recommendation Overall, eleven of the 13 respondents find that the use of the curriculum workshop method would be recommendable when creating a new interdisciplinary degree program (8 of 13 "Yes, definitely"; 3 of 13 "Yes, probably"). Only two of the 13 respondents find the method is rather not recommendable.

5 DISCUSSION

Curriculum workshops in an interdisciplinary setting

Overall, the curriculum workshop method can be considered a suitable format for interdisciplinary curriculum development. It enables a creativity-promoting exchange format, the collection and specification of ideas with the participation of the disciplines involved and does not require guidelines from existing study programmes. The evaluation results indicate that considering individual interests and planning sufficient time for it is a key consideration in interdisciplinary cooperation in the workshop sessions. Moreover, it is important to tackle certain tasks and questions several times to allow participants to take different perspectives. At the same time, participants felt their interests were sufficiently taken into account and they could participate productively throughout the workshop series.

The experiences of our case study indicate that the curriculum workshop method is suitable for creative brainstorming and creating a consensus but not so much for the concrete formulation of outcomes, e.g. in descriptions of a profile or module. In our experience, connecting the findings and creating condensed outcome reports, and discussing them within the next session has been a way to move forward and not get stuck in detail. Concerning working with different cultures, backgrounds and experiences, it has shown important to create a mutual understanding of the topics, e.g. through giving input or context.

Limitations of the study The presented study has three limitations. First, the presented evaluation and finding stems from the implementation of one curriculum workshop series. Therefore, conducting it in another setting would give more insights into the generalizability of the findings. Second, the study focused only on the process of development, not the quality of the outcome. Third, throughout the development, the participants that took part in the workshops were not fixed. Thus, we asked participants to evaluate the whole approach as a workshop series, not single sessions.

Implications for the community The study can give new impulses for instructors, curriculum developers, and faculties on how to approach interdisciplinarity in curriculum development, especially with a focus on bringing AI into engineering education. This addresses the question of what knowledge and skills are relevant for future engineers to be prepared for their future jobs (Gumaelius and Kolmos 2019; Millar 2015). Moreover, findings and considerations from this study can be transferred into interdisciplinary curriculum developments at other future trends, such as the intersection of sustainability and engineering.

6 CONCLUSION AND FUTURE WORK

In this paper, we focused on investigating how well the curriculum workshop method is suited for the development of interdisciplinary curricula at the intersection of AI and engineering with regard to interdisciplinarity, cooperation, participation, and composition. Moreover, we looked into key considerations in implementing the curriculum workshop method in an interdisciplinary setting. In analyzing the use of curriculum workshop sessions in the development of a novel bachelor program at the intersection of AI and engineering, we found that the method is a suitable format for an interdisciplinary curriculum development. Its strength lay in a collaborative and structured working environment that allows taking into account multiple disciplinary perspectives. Moreover, it can be adapted to the needs of each group. At the same time, the evaluation indicates that the method is suitable to create new insights but not so much for the concrete formulation of outcomes.

Further research will evaluate the outcome of the curriculum development through competency mapping. Moreover, further studies could investigate how input and feedback from different stakeholders such as industry partners and practitioners can be included in curriculum development approaches to ensure relevance and applicability.

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