Making sense of interdisciplinarity in challenge-based learning: A two-step co-creation approach towards educational redesign

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Conference Key Areas: *Student Engagement, Co-creation with students*
Keywords: *challenge-based learning, interdisciplinarity, project-based learning, learning experience, co-creation*

ABSTRACT

Challenge-based learning gains popularity in engineering education for allowing students to transcend academic and disciplinary boundaries and to fully engage in real-world problems, but it is largely underexplored how to improve specific designs of such educational practices to promote interdisciplinary learning experiences and competencies. This paper describes two studies that together in two steps make up an evidence-based redesign of a challenged-based course featuring group-work projects in an undergraduate program combining engineering with liberal arts and sciences. A first study based on observation and interviews collects different and varying learning experiences throughout students' learning activities. The results showed that interdisciplinary experiences are constructed in complex dynamics between students' disciplinary identity formation and the interdisciplinary and collaborative course configuration. Such dynamics may result in positive learning

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doi:10.5821/conference-9788412322262.1195

experiences (engagement and interdisciplinary enrichment) as well as negative ones (disengagement and frustration). Especially regarding the discrepancy between common experiences across the three phases of tackling the challenge (mapping, mitigating, integrating), representatives of parties important for the course were invited to a roundtable session in a second study to discuss and reflect on the first study's findings and what they can mean for the course design. Understandings achieved in the session are used as input for upcoming course redesign towards a more desirably organized challenge-based learning. The two-step approach towards redesign is an example of involving researchers and students in evidence-based educational redesign, exemplifying the value of naturalistic research and educational co-creation in understanding and optimizing students' learning experience to achieve fruitful challenge-based learning.

1 INTRODUCTION

Our rapidly changing world calls for experts who can transcend traditional disciplinary regimes. Academic programs increasingly try to incorporate interdisciplinary elements in their curricula and there is a growing number of programs with an overall interdisciplinary signature. Challenge-based learning is a dominant approach in weaving interdisciplinarity in academic education [1]. Still, little is known about the way challenged-based courses contribute to interdisciplinary learning experiences and competencies. Analyzing how students reflect on their interdisciplinary learning experiences in specific challenged-based courses may provide insights in the strengths and weaknesses of such forms of academic education and help to identify course design characteristics with positive or detrimental effects on the development of interdisciplinary competencies.

This paper presents a case of understanding the interdisciplinary experience in challenge-based learning and applying such understandings to improve challenge-related educational design. The study focuses on a specific project-based course in a Dutch Liberal Arts and Science (LAS) undergraduate program. The entire program emphasizes students' self-determination and interdisciplinarity, allowing students to tailor unique academic trajectories based on personal pursuits and bringing students with different academic interests and backgrounds together in collaborative project settings. One of its courses, called Real-World Challenges, aims to prepare students for working on grand and wicked problems on a scale similar to real-world contexts. This 19-week course gives students substantial freedom in contributing their own interests and expertise to addressing societal challenges. Students themselves choose the specific topics to work on and accordingly form groups. In one semester, the groups try to diagnose and ease the challenges by developing interventions through, citing the syllabus, 'multidisciplinary solutions and systems thinking.'

Besides the preparing week during which students determine project topics and groups, the course consists of three phases. In the first phase (Mapping and Modelling, 5 weeks), groups of around 14 students analyze the challenge as a complex spatial-temporal system from different angles, decomposing it into heterogenous constituents, and comprehensively mapping and modeling it by describing involved critical issues, stakeholders, and their interrelations. In the second phase (Mitigation, 9 weeks), the groups divide into smaller 'expert teams' of two to four students. Expert teams apply their specialized expertise to devise mitigation strategies for the identified critical issues towards solving the general problem. In the third phase (Integration, 4 weeks), students return in the large group to attune and synthesize separate mitigation strategies into a collective final report that addresses the challenge in line with the overarching model made in the first phase.

Since the start of this LAS program more than eight years ago, this challenge-based course highlighting student autonomy and interdisciplinary exchange has undergone little change in design. In 2020, it participated in a practice-based educational research project, STRIPES2021 (STructuring Interdisciplinary Projects for

Engineering Students), which is supported by COMENIUS Leadership Fellows and aims to help educators better structure interdisciplinary education.

2 METHODOLOGY

Studies regarding the interdisciplinary nature of course were conducted in two steps. The first step featured of an in-depth qualitative research on students' learning experiences and perceptions of interdisciplinarity. The study engaged in classroom practices and especially focused on how interdisciplinarity emerged as cognitive-social systems through the process of challenge-based learning and project work [2]. Building on 35.5-hour observation of class and group meetings and informal talks with students, further interviews (N= 25) were conducted with students from the 2020 cohort. The interviews focused on the design and process of the project work, students' disciplinary identities, and their learning experiences throughout the course. This step served to develop a detailed overview of the strengths and pitfalls of challenged-based interdisciplinary education in such a free, autonomous setting.

The second step involved a roundtable session meant to provoke insights for possible redesigns of the course. The session invited a course coordinator who developed and supervised the course and two students from different years who had followed the course in different years. By involving the two groups, this step emphasized a student-staff partnership and followed a co-creation approach which directly enables the exchange between different knowledge and experience in education and reinforces the values of equity and interaction [3], as the program itself highlights. In the session, the participants were gradually presented with findings of the first study and brought into discussion. Along the demonstration of research findings, students were encouraged to share and compare their learning experiences, which simultaneously validified the first-part research findings by recognition. Participants structurally discussed, brainstormed, and reflected upon the research findings and what they may mean for the educational design of SP4. Therefore, the research findings were communicated with the educational community of the program highly respecting its autonomy and culture. The roundtable session resulted in a report about possible ways towards improvement and challenges to further investigate and address mentioned in the discussion. This step served to bridge the gap between research findings and the educational practice as well as to deepen the insights about the stakeholders' perceptions of interdisciplinarity in academic education.

3 RESULTS

3.1 Naturalistic study: identifying problems

Researchers' engagement in the first study showed variations of students' learning experiences in the course, both in a vertical dimension through three phases and in a horizontal dimension across individuals, particularly in the second phase, Mitigation. Analyses focusing on the horizontal variation have resulted in a detailed account about how interdisciplinarity has been constructed and enacted in this

specific educational context where individual disciplinary identities manifest, negotiate, and act upon each other in the interactive groupwork dynamics. One an individual level, students showed different identities in how their academic pursuits were configured regarding disciplinary constellation. Working in expert teams, different patterns of group-work experience regarding interdisciplinarity emerged following various circumstances. The interplay between individual levels and group levels illustrates dynamics of interdisciplinarity in the course, partly orchestrated by the project design and partly shaped in concrete interpersonal transactions.

While in another publication we addressed intersectional academic identities and their construction of interdisciplinarity in details, we are also interested in the practical implications of our explorative and descriptive research regarding learning experiences for the design of the challenge-based course. The implications firstly concern the horizontal variation in learning experiences: During the mitigation phase, not all students shared a fruitful interdisciplinary experience. Instead, some students missed meaningful connections with other disciplinary input and considered their experience as monodisciplinary: ‘But then you had the mitigation strategy in the mitigation phase …[I] didn't experience it really like that [interdisciplinarity] because I was just working on my own expertise. So, I didn't really feel very interdisciplinary’. Other students expressed an experience of shallowness and not being able to apply their expertise: ‘I have the feeling that, for example, I got to apply some of my expertise, but a lot of it I also just have to look up online… [the topic] was what we were interested in. But it wasn’t necessarily that we applied the knowledge that we already had. We had to gain more knowledge before being able to apply it. In that sense, in my opinion, it isn’t really about the interdisciplinarity at that point. It’s just more about Googling.’ This non-disciplinary experience as well compromised the engagement of students.

Furthermore, the vertical variation of perceiving interdisciplinarity also matters in how students experience their learning journeys. Unlike the various patterns identified in the Mitigation phase, students shared large commonalities in how they experienced SP4’s first and third phases. When the beginning Mapping and Modelling phase is commonly described as brainstorm and discussions full of exchanges between different disciplinary backgrounds, the third, named and emphasized as ‘Integration’, is surprisingly characterized by a lack of engagement, interaction and interdisciplinarity in students’ experiences.

External factors such as heavy end-semester study load and communicational constraints during the Covid-19 crisis partly explained this problem. However, interviews yet showed that practices during the Integration phase were fairly limited to repeating the maps and models from the first phase. Similarly restrained were freedom, creativity, and flexibility regarding project work from which student have expected much. Some students questioned whether different approached were brought together during the integration phase and accordingly distanced themselves from taking tasks. Many students, similarly, contributed solely by summarizing their Mitigation-phase achievements without an overview of the whole project. Students

often commented the Integration phase as mainly revising and editing documents, a mechanical process without actual mental challenges or growth to understand or synthesize different perspectives.

3.2 An analysis of the problem and educational design

Reflecting upon the structure of the course, the three-phased project design in addressing challenges implies a sense of reductionism and linearity, which related to students' disengagement during the Integration phase. Primarily, the three phases are demarcated based on an assumption that complex problems are aggregations of affiliated issues that connect but can be dismantled, tackled separately, and later brought together. Groups, in Mapping and Modelling, were asked to sort out various nodes in models and reduce holistic problem maps into jigsaw pieces. Therefore, what the large group achieves in this first phase largely determines following activities. Integration, consequently, becomes the closing section in a ternary form that repeats the opening, mainly patching together the previously defined critical issues, focusing hardly on content but formation of the final assignment documents.

Second, projects' three phases demonstrate a sequential, linear structure: One follows the other in time. However, the linearity cannot capture the logic behind the phases. When mapping and modelling problems, students were already asked to envision specific critical issues and consider their interlinks. Concerning Integration, the syllabus also suggested 'reflect[ing] on how the mitigations of the smaller phase-2 groups can be integrated in the original models of the overarching problems', explicitly referring to the two earlier phases. Therefore, the three phases are actually interwoven and symbolize recurring moments and iterative processes facing complex, holistic systems. The inconsistency between the time-wise linearity and logic-wise non-linearity in SP4's educational design actively acts upon students' learning experiences.

This reductionist and linear assumption also renders the Mapping and Modelling phase dominant impacts on the group dynamics and interdisciplinary experiences throughout the project. Specifically, the composition of expert teams in Mitigation largely complied with the underlying logics of initial problem definition and critical-issue division. When critical issues are framed as disciplinary aspects, corresponding expert teams are likely to be homogeneous, with members sharing similar disciplinary focuses. Contrariwise, identifying a critical issue as a specific phase or facet of the larger problem stimulates groups to recognize problems' interdisciplinary nature and promote miscellaneous teams allying distinct disciplinary expertise. In homogeneous and miscellaneous groups, where respective critical issues are established and approached differently, work dynamics also take place differently, leading to different perception and experience of the application of disciplinary expertise, transactions across disciplines, and thus interdisciplinarity.

3.3 Roundtable session: creating input for change

Empirical findings about students' learning experience and theoretical reflection on the course's set-up were together brought into the roundtable session to create an

environment for discussion, reflection and co-creation. In the session, the researcher acts both as a party in the co-creation that provide outsider insights and as coordinator to facilitate the communication and encourage others to come up with possible ways to improve the course. When sharing the research findings about learning experience, both the compromised interdisciplinary experience (non-disciplinary and monodisciplinary) and the disengagement in the Integration phase were recognized by students from experiences of themselves and peers. For example, one student described the Integration phase as 'more like mixing and matching the parts in a report rather than trying to understand [different perspectives].' The analysis of the reductionism and linearity implied in the design to address challenges was also endorsed by both educators and students as a critical problem in designing interdisciplinary and challenge-based education.

The roundtable session first identified the links between different expert teams as the key to overcoming the problem in educational design and to improvement of the course. Although students expressed that 'integration feels a bit rushed in the end' and believed if given more time they would be able to experience more meaningful learning in the Integration phase, prolonging the Integration phase does not mean the definite solution: Students need to read into mitigation strategies of other teams during the extra time, thus a better in-depth understanding of other teams' work is pivotal for meaningful integration.

Consequently, the discussion focused on possible ways to enable links between expert teams and resulted in several proposals for educational (re-)design.

First, activities during the small-team-based mitigation phase could be planned to allow students to learn about others' work in an earlier phase and make connections. One example is a mitigation strategy market, where all expert teams would present their work by far and students could then walk around to talk with peers, sharing ideas and comments, pinpointing possible links between different disciplinary perspectives, and helping each other shape further mitigation trajectories. Similarly, a mid-term evaluation halfway at the Mitigation phase can give students chance to present their work at the current stage. Guided by course coordinators or external experts, open conversations during such an evaluation moment can involve more peer teaching and explanation from different disciplinary perspectives, so that individual members in expert teams can understand work in other teams better and identify links with other teams more easily in a more structured way.

Second, it is recognized that the challenges identified at the preparation phase of the course are too broadly defined. The elements and expertise recognized in the initial mapping and modeling of the challenge are impossible to be reasonably covered by four to six expert teams. Therefore, the mitigation phase can only attend a few knots on a web-like model and a lot in the model will be omitted in the whole Mitigation phase. According to students, even one critical issue treated in an expert team now is complex enough and have many perspectives to be qualified as a topic of challenge for the whole large group. A watered-down approach is proposed to better decide on the topic of challenge: After identifying different critical issues of a general,

broad grand challenge, the group would further focus on one critical issue and repeat the mapping-modelling process until the resulting model is manageable for the group with a limited number of members. By narrowing down the scale of the challenge, students could also further engage together in connections between and among different aspects and perspectives of a problem, thus have a firmer base to integrate different mitigation strategies.

Therefore, the integrative endeavor is less emphasized or concentrated as the last phase of the challenge-based project work but is present throughout the entire course. In other words, the whole project is actually focusing on integration, not only in the last phase. This shows that specialization and integration are two simultaneous aspects in addressing challenges, not to be separated in time or activities. To accomplish the proposed (re-)designs for the course, educators need to either transcend the reductionist, linear curriculum design or instruct and scaffold closely through the first phase, from defining the scale of the challenge to the forming of expert teams.

4 SUMMARY AND ACKNOWLEDGMENTS

This paper, based on a case, described a two-step approach that brings educators and students together to reflect on a challenge-based course and together create improvement for the course in the future. In this co-creation approach, researcher functions both as mediator and catalyst. On the one hand, the researcher collects learning experiences that are used as input to help represent a student perspective for educational improvement. On the other hand, the researcher brings individuals from different positions in education together and facilitate the intensive discussion and reflection. Therefore, this two-step approach shows how the sociological, naturalistic epistemology and methods of social studies can contribute to educational practices. Unlike the researcher-centered approach commonly found in educational design and improvement, the two-step approach presented here puts educators and students who are directly involved in the learning practice at the center. Therefore, this paper demonstrates an initiative to engage different stakeholders, especially students, in educational design. The highly emphasized engagement in the co-creation approach also respects and complies with the values about student-involvement, autonomy and community favored by this LAS program.

This study is part of the COMENIUS Leadership Fellows 2019 project: STRIPES2021. We thank the program and all involved educators and students for their help.

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