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To Withdraw, Investigate, Negotiate Or Integrate? Students' Coping Strategies With Disorienting Dilemmas In Interdisciplinary Project Courses

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TO WITHDRAW, INVESTIGATE, NEGOTIATE OR INTEGRATE? STUDENTS' COPING STRATEGIES WITH DISORIENTING DILEMMAS IN INTERDISCIPLINARY PROJECT COURSES

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ABSTRACT

In today's rapidly changing and increasingly interconnected world, engineering educators are required to implement active pedagogical approaches to support students' interdisciplinary problem-solving processes. However, interdisciplinary and experiential learning may evoke situations where students question their past learnings and even existing values, beliefs, or assumptions. Our study examined the emergence of "disorienting dilemmas", a central concept to transformative learning theory, and students' experiences in coping with them in engineering education.

We interviewed ten students from two interdisciplinary project courses at School of Engineering in Aalto University, Finland, and conducted thematic analysis to identify the types of disorienting dilemmas and the coping strategies that students employed. Our study found that students experienced disorienting dilemmas related to self-beliefs, approaches to real-world challenges, teamwork, and disciplinary differences. To cope with these dilemmas, we identified four key strategies that reflected different levels of cognitive-behavioral responses: withdrawing, investigating, negotiating, and integrating.

Our study contributes to transformative learning theory by extending the understanding of disorienting dilemmas in the context of interdisciplinary project-based education. We also provide practical implications for engineering educators seeking to develop students' competencies to effectively address complex challenges in working life. Effective interventions, such as critical reflection, open discussion, and resolving conflicting perspectives, can help students navigate disorienting dilemmas and enhance their interdisciplinary and transformative learning. Future research can explore how students' team characteristics may affect the emergence of coping strategies identified, as well as investigate the impact of scaffolding on students' learning outcomes.

1 INTRODUCTION

The complex societal and environmental challenges call for higher engineering education to equip graduates with key competencies that allow them to adapt to emerging technologies, collaborate across disciplines, and navigate the ethical and social implications of their work (Vehmaa et al., 2018). As such, engineering educators are increasingly applying innovative pedagogical approaches, such as interdisciplinary teaching, project- and problem-based learning, to facilitate students to learn from diverse perspectives, tackle complex problems, and think critically. However, such approaches may also bring obstacles: students can experience difficulties in tackling an unknown problem that requires reflective practice and connecting with epistemologies and discourses that are different from their own (Feng & Hölttä-Otto, 2021; Kabo & Baillie, 2009). While less is studied on how students experience and cope with these challenging situations, it is essential to gain a deeper understanding of student experiences in order to provide support for students learning.

1.1 Defining disorienting dilemmas

The disorienting dilemma concept derives from Mezirow's transformative learning theory, which describes the process of learning through contradictions (Mezirow, 1978). This dilemma is typically the starting point of the transformative learning process and takes place when learners experience a profound sense of dissonance or uncertainty that prompts them to question their prevailing values, beliefs, or assumptions - essentially, the *frame of reference* through which they understand the world. Transformation is achieved when learners critically examine their existing frame of reference and replace it with a new one. This process is considered vital for enhancing critical thinking (Thomas, 2009), fostering greater self-awareness (Jaakkola et al., 2022), and cultivating an overall increased tolerance for uncertainty and ambiguity. These competencies are crucial for effectively responding to sustainability challenges in working life (Rieckmann, 2012).

1.2 Understanding disorienting dilemma in interdisciplinary project courses

Having one's existing frame of reference challenged can cause feelings of discomfort. For instance, Lönngren et al. (2016) identified a high degree of frustration in engineering students when they were tasked to address ill-structured problems due o them requiring different cognitive processes compared to the well-structured problems. Particularly in interdisciplinary engineering education, where project courses integrate engineering, design, and other studies, students are exposed to highly different paradigms or methods (Dym et al., 2005; Hart, 2009). They are required to learn the established techniques that converge to develop 'accurate' answers and uncover 'facts'. At the same time, they need to think in a divergent manner and explore alternative solutions to the problem (Dym et al., 2005). In response to such situations, individual students may exhibit diverse reactions, which in turn can also influence the whole team's coping mechanisms (You, 2023).

Although existing studies have perennially reported students' transformed outcomes of interdisciplinary courses (Tien et al., 2020; Kabo & Baillie, 2009), transformation is not always guaranteed, and not all learning can be considered transformative (Hoggan, 2016). Studies examining transformative learning in interdisciplinary contexts have primarily reported the outcomes of student learning, while neglecting the processes of students resolving disorienting situations. Studying how students encounter disorienting dilemmas and cope with them is the first step toward an in-depth understanding of the key conditions enabling learning transformations where students are more open to various parallel conceptualizations. Therefore, in this paper, we examine students' experiences of disorienting dilemmas in interdisciplinary project courses and their initial responses to them.

Given the quest for providing students with broadened and transformed points of view, our study answers two research questions: (1) what types of disorienting dilemmas do students experience in interdisciplinary project courses, and (2) how do students cope with these dilemmas?

2 METHODOLOGY

This study employed a qualitative case study research design to explore students' learning experiences in interdisciplinary project courses, focusing on how they encounter and cope with disorienting dilemmas. As there are limited studies on students' responses to disorienting situations, qualitative research design was used to gain a better understanding of the phenomenon (Creswell, 2012). Furthermore, we used a multiple-case study methodology to examine different aspects of the phenomenon and analyze the intricate relationships between phenomenon and context (Yin, 2009). Multiple case studies help explain similar results in the studies or argue contrasting results for expected reasons (Yin, 2009). The case study methodology is particularly relevant for the explorative and descriptive nature of the study.

2.1 Data collection

The cases were selected on the basis of their interdisciplinary and project/problem-based characteristics. We targeted courses where students work in interdisciplinary teams to address a joint, real-world problem with external partners from industry and academia. The chosen cases include two master's courses at a Nordic university. Data was collected through an online background survey on their academic and professional background and semi-structured individual interviews conducted by two of the authors. The interviews focused on the emergence of and responses to situations or scenarios where students' assumptions, beliefs, ways of thinking or working were challenged while working on their projects. The interview protocol consisted of open-ended questions designed to elicit detailed responses from the participants about their learning experiences. The interviews lasted approximately 1 hour each and were audio recorded and transcribed verbatim with the consent of the

participants. All participants were assigned pseudonyms in data handling process according to the research integrity guidelines.

2.2 Participants

We used purposive sampling to ensure a diverse group of master's students that worked in teams with various disciplinary backgrounds represented, including business, engineering, architecture and design. Students were selected based on their willingness to participate in the study and their availability for an interview 1-2 months before the end of their course. A total of ten students from various design (n=4) and engineering (n=6) disciplines participated in our study. Examples of the disciplines include industrial design, electrical engineering, and mechanical engineering. The students were all participating in one of the two courses studied. Five students attended a problem-based learning course that focuses global sustainability challenges with partners from the industry and academia, while the remaining five studied in a project-based learning course focused on working with real clients on product development. All except two students had less than three years of previous experience in working in interdisciplinary teams at the time the interviews were conducted.

2.3 Data analysis

The initial analysis is informed by an open coding approach (Strauss & Corbin, 1998) identifying patterns and themes that are relevant to our research questions while remaining "open to all possible theoretical directions" (Charmaz, 2006). We continued data analysis with focused and axiel coding iteratively to develop the "most salient categories" in understanding disorienting dilemmas and coping strategies (Charmaz, 2006). Two researchers independently coded the transcripts. Together with the third author, the emerging codes, categories, and themes were discussed through peer debriefing to ensure inter-coder reliability and trustworthiness of the analysis (Lincoln & Guba, 1985). Any discrepancies in coding were resolved through discussion until a consensus was reached.

3 RESULTS

In this section, we present the types of disorienting dilemmas that students encountered in their projects, followed by descriptions of the cognitive-behavioral responses that form the coping strategies of students to those dilemmas.

3.1 Disorienting dilemmas

Four types of disorienting dilemmas emerged from students' responses to their experiences in working in projects: i) beliefs about self, ii) approach to the real-world challenges, iii) approach to teamwork, iv) and understanding of disciplines.

The first type of disorienting dilemma pertains to situations in which students feel that the course has challenged their pre-existing beliefs about themselves and their values. For example, when asked to identify their professional or disciplinary identity, some students struggled to fit themselves into traditional engineer roles, leading them to

question what type of engineer they truly are. Additionally, students described how their previous understanding of sustainability issues was challenged by the project, encouraging them to reassess their preconceptions.

The second type of disorienting dilemmas related to the approach to real-world challenges. Students found open-ended problems given by the course partners more difficult to disentangle compared to well-structured problems they are used to solve. Furthermore, they experienced discomfort with the hands-on aspect of the project, which was a departure from their more theoretical studies. Balancing priorities between the team and external partners when coming up with solutions to problems also caused confusion.

The third type of disorienting dilemma was related to the collaborative nature of teamwork. Students described situations where frustration and confusion arose in team settings, which differed significantly from their prior experiences with teamwork.

The final type of disorienting dilemma concerned differences in disciplinary understanding. Students observed epistemological differences that emerged due to differing disciplinary points of view. For example, some students found it challenging to reconcile differences in how engineers and designers justified evidence. They also discovered that their preconceptions about the know-how of colleagues from different disciplines were often inaccurate.

3.2 Coping strategies

Four types of coping strategies towards disorienting dilemmas emerged from our data: withdrawing, negotiating, investigating and integrating. While analysing their characteristics, we found that the four coping strategies include differing behavioral and cognitive responses: these two dimensions can be described as a matrix presented in Table 1. On the behavioral response dimension, students' responses range from reactive to proactive actions: while some students responded by not engaging with the dilemma, others took a more proactive approach to engage with different frames of references. The cognitive responses ranged from maintaining to sense-making: some students resorted to only acknowledging different frames of reference but retaining one's existing beliefs and assumptions, while others responded cognitively by accepting and trying to make sense of new points of view.

Table 1. Cognitive-behavioral responses of students to disorienting dilemmas in interdisciplinary project courses: i) withdrawing, ii) negotiating, iii) investigating, and iv) integrating.

COGNITIVE RESPONSE	BEHAVIORAL RESPONSE: Reactive	BEHAVIORAL RESPONSE: Proactive
Maintaining	*(withdrawing)* • Understanding and making space for the more "competent" • Resigning due to different ways of collaboration	*(negotiating)* • Attempting to correct "wrong" assumptions or ways of thinking by others • Utilising disciplinary competencies to showcase one's perspectives
Sense-making	*(investigating)* • Understanding the definition of the problem • Questioning the approach to problem-solving • Reflecting the problem from different perspectives	*(integrating)* • Reframing the problem by assessing and balancing students' and the external partner's priorities • Synthesizing different ways of thinking or working between disciplines • Creating an environment that encourages integration of views and ways of working

Withdrawing from the dilemma refers to situations when students acknowledge different frames of reference but choose not to engage with the dilemma. For instance, one design student mentioned that engineers had a different approach to problem-solving. Rather than engaging in co-creation with the engineers, the design student decided to give engineers the space to "do their thing". Similarly in another example, a student thought "it was not worth" to attempt changing teamwork habits of others when their expectations of collaboration were not met and therefore "stopped trying".

Compared to *withdrawing*, *negotiating* emphasizes one's proactive efforts in demonstrating one's perspectives. This coping strategy was particularly prevalent to dilemmas where students saw that others had misconceptions about their disciplinary functions. For example, in one team where a student observed others having preconceptions about design being mainly related graphics, the student had to stand up and find ways to communicate that it was the "wrong" way of seeing design, design research, and designers. Similarly, an electrical engineering student felt that other team members had a preconception of electronics as being "plain magic". The student decided share resources such as videos for others to understand better what their discipline is about. Another example is from a design student, who made efforts in clarifying their points of view and convincing others to understand through design competencies. When the team asked the design student to work with the prototype measurements, the student realized that it was not possible to do it, but others did not understand. The design student was able to quickly put together a mock-up with paper and drawing to demonstrate the infeasibility of the measurements to the team.

Besides maintaining one's views and ways of working, we found that students also engaged in a sense-making process, *investigating* the project's problem as well as different points of views and approaches to solve the problem. Students were able to reflect and question the definition, the approach, and different aspects of the problem. They paid attention to the problem at hand, by asking questions among themselves and from the external partner to understand and define the problem. For instance, one student challenged their teammates to view the open-ended problem which the student initially found confusing by asking questions on how it could be viewed from different angles. In another project where students were tasked to address a sustainability challenge, they recognized the need to also consider reflecting on other dimensions of sustainability beyond the environmental one which they were the most familiar with from their past studies. When confronted with a dilemma that prompted a student to question their own understanding of sustainability, the student's response was to investigate further why they think a certain way and how might this expanded understanding fit into their frame of reference.

Some students coped with the dilemma through *integrating* to combine different perspectives and ways of working. For example, in dilemmas where students observed potentially conflicting values and demands in designing a solution to fit the partners' needs, students were not only able to acknowledge those values and demands but also actively strived to balance them. One student shared that although there might be clash, there needs to be a continuous effort towards making the solution acceptable to partners while still feeling "good about your outcome". In another example, a student described how their team strived to actively facilitate a "safe environment" for sharing potentially differing views through explaining what they think and why they think a certain way, and everyone should be open to modifying their own views in order to reach a consensus. Furthermore, a student shared an example where, although they (an electrical engineer) and a service designer shared very different views on the problem-solving process, they opted for combining the tools they used for project building.

4 SUMMARY

For engineers, addressing real-world problems while working with a multitude of perspectives can be disorienting. Therefore, engineering educators need to support students to respond appropriately to those disorienting scenarios, be open to new perspectives, and develop greater tolerance for uncertainty (Joslyn & Hynes, 2022). To build foundations for designing educational interventions and providing the kind of support needed for students, our study looks into students' experiences of the disorienting dilemmas and their coping strategies.

We extended transformative learning theory by identifying different types of disorienting dilemmas in interdisciplinary project courses. These include dilemmas about self-beliefs, ways to approach real-world challenges, teamwork, and disciplinary understandings. We also found students' diverse approaches to cope with the

dilemmas. The results suggest pathways for engineering educators to engage students to reflect and collaborate across disciplines more effectively. Particularly, when students *withdraw* from the dilemmatic situations, educators can scaffold students in critically reflecting on their assumptions, beliefs and ways of working, for instance, through mentoring or tutoring. Students can also be guided to *investigate* the problem further and *integrate* different disciplinary perspectives and stakeholders' points of view within their project context. By acknowledging these diverse cognitive-behavioral responses to disorienting dilemmas, engineering educators can become more informed to provide appropriate facilitation for interdisciplinary and transformative learning processes.

Our study focused on identifying individual-level dilemmas and coping strategies within a specific institutional context which may limit the generalizability of the findings. Further research can build on our findings by identifying key factors, such as prior experiences, team composition and project brief, affecting the emergence of coping strategies identified. Simultaneously, it is worthwhile to examine how educators can scaffold certain coping strategies that lead to transformative learning outcomes.

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