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Students' experiences in an interdisciplinary module: “It’s like travelling to a foreign country”

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Abstract

This exploratory qualitative study examines the experiences of 15 Bachelor’s students in an extracurricular interdisciplinary module (140 hours, 8 weeks) alongside their monodisciplinary Bachelor’s programme. We conducted semi-structured interviews to analyse 1) how students perceive their participation in an interdisciplinary module, focusing on the factors that challenge and motivate them, and 2) their perceived learning outcomes from participating in the module. Thematic content analysis revealed that students feel challenged by acquiring knowledge and skills from other disciplines, but struggle with mastering new terminology. Connecting with prior knowledge is stimulating, while repetition and lack of connection hinder motivation. Students’ perceived learning outcomes include having gained insights into other disciplines and obtained understanding of different disciplinary perspectives. They also recognised improvements in communication skills and the value of interdisciplinary collaboration. Further research could explore students’ learning process in a full Bachelor’s programme (instead of one module) and examine the relationship between actually attained and perceived outcomes of interdisciplinary education. As a practical implication, we suggest three guiding principles for interdisciplinary teaching at Bachelor’s level: ground, contrast, connect.

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Practitioner Notes

1. Researching students' perceived learning outcomes is key to uncovering insights into teaching and interdisciplinary learning and identifying gaps between intended, perceived and attained outcomes.
2. Prioritise common grounding in interdisciplinary learning by connecting new content to students' prior disciplinary knowledge to ensure engagement and meaningful connections.
3. Give active attention to contrasting disciplinary perspectives in interdisciplinary teaching by encouraging students to identify both differences and similarities between academic disciplines.
4. Encourage students to build on their existing knowledge by connecting insights from other disciplines to their own, and using their expertise to enhance other fields.
5. Conduct follow-up research to explore the phases of acquiring interdisciplinary understanding and develop a phased framework for curriculum design to better support student learning across disciplines.

Keywords

Interdisciplinary education, student experience, perceived learning outcomes, qualitative methods

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Introduction

In the past decade, European research universities have increasingly incorporated interdisciplinary education into their strategic agendas (Lindvig et al., 2019; Lyall, 2019; Lyall et al., 2019). This emphasis on interdisciplinary learning is largely driven by the complex, multifaceted challenges that our global society is confronting (e.g., Blackmore & Kandiko, 2012; Lyall et al., 2015; Manathunga et al., 2006). Issues such as climate change, economic inequality, and rapid technological advancements extend beyond traditional disciplinary boundaries, demanding innovative, cross-disciplinary approaches to address them effectively. Interdisciplinary education is often viewed as a promising mean to equip students with the knowledge and skills necessary to tackle these pressing issues (e.g., Howlett et al., 2016; Oudenampsen et al., 2024; Spelt et al., 2009). While interdisciplinary education has gained prominence in strategic agendas, European research universities face significant challenges in implementing effective interdisciplinary education, as these institutions have traditionally operated within monodisciplinary structures (Lyall et al., 2015; Lyall, 2019; Nandan & London, 2013). These challenges include, for instance, fostering collaboration between departments, adopting new approaches to curriculum design, and providing professional development opportunities for staff educated within monodisciplinary frameworks.

Given its widespread implementation, popularity, and potential of interdisciplinary education to address complex challenges, there is a growing demand for evidence-based research into the implementation of interdisciplinary teaching and learning (e.g., Lindvig et al., 2019; Lyall et al., 2015; Lyall, 2019). The student voice has been underrepresented in research on the implementation of interdisciplinary education, leading several researchers to emphasise the importance of incorporating the student perspective (Gombrich & Hogan, 2017; Lattuca et al., 2004; Spelt et al., 2009). Our study responds to their call by including students' experiences and perceived learning outcomes of interdisciplinary learning within the context of a monodisciplinary-organised research university.

The research university being studied is an example of a European research university that has made interdisciplinary education one of its strategic goals. The university has initiated a series of projects to test the implementation of interdisciplinary education within its traditional monodisciplinary structure. One of these initiatives is an extracurricular interdisciplinary programme for high-achieving Bachelor's students consisting of 45 ECTS credits (1260 hours)1. The extracurricular programme spans five semesters and runs alongside students' regular monodisciplinary Bachelor's programmes, which comprise 180 ECTS credits over six semesters.

Students who have achieved a ranking within the top 10% of their monodisciplinary Bachelor's programme during the first semester of their study are invited to apply (voluntarily) for a place in the extracurricular interdisciplinary programme. Each year, approximately 300 students from 45 different monodisciplinary Bachelor's degree programmes are admitted to the extracurricular

[1] The European Credit Transfer and Accumulation System (ECTS) is a credit system used in the European Higher Education Area (European Commission: Directorate-General for Education, Youth, Sport and Culture, 2015). 1 ECTS credit corresponds to 28 hours of study activities, including self-study. 60 ECTS credits are equivalent to one full-time year of study.

interdisciplinary programme. More details about the programme are provided in the Method section.

From a curriculum development perspective, the curriculum can be conceptualised through four distinct dimensions: the intended, enacted, attained, and perceived curriculum. This framework can be applied to learning outcomes of individual modules (e.g., Clemmons et al., 2022; Hume & Coll, 2010; Laboute et al., 2019): intended learning outcomes define the planned educational objectives, enacted learning outcomes reflect how lecturers operationalise these objectives into teaching practices, attained learning outcomes represent the knowledge and skills students demonstrably acquire as tested by assessment, and perceived learning outcomes reflect students' perceptions on what they have learnt. The current study focuses on students' experiences and their perceived learning outcomes as this perspective provides valuable insights into the interdisciplinary learning process. These insights can highlight the desired alignments and potential misalignments between intended and attained learning outcomes.

In the presented study, we focus on optional thematic modules worth 5 ECTS credits (140 hours) in the second year of the extracurricular interdisciplinary programme. This is one of the first thematic modules that the students take. Students can choose one from 13 different optional thematic modules (e.g., criminal behaviour, plastic pollution, and global inequality). We elaborate upon this in the Method section. The current study critically examines interdisciplinary learning from the students' perspective by conducting in-depth qualitative research into students' experiences within these modules. Our study addresses the following research questions:

1. How do Bachelor's students experience their participation in a 5 ECTS credits (140 hours) extracurricular interdisciplinary module in terms of the factors that challenge and motivate them?
2. What are Bachelor's students' perceived learning outcomes from participating in a 5 ECTS credits (140 hours) extracurricular interdisciplinary module?

Literature

In this literature review, we first discuss the concept of interdisciplinary understanding as one of the intended learning outcomes of interdisciplinary education. We then review the findings of previous studies on students' experiences with and their perceived learning outcomes of interdisciplinary education.

Interdisciplinary understanding as learning outcome

When considering students' experiences and perceived learning outcomes within interdisciplinary education, it is crucial first to discuss the literature regarding the intended learning outcomes of interdisciplinary education as these (ideally) guide the teaching, student learning and chosen assessment forms (Biggs, Tang & Kennedy, 2022). As identified in review studies (Oudenampsen et al., 2024; Spelt et al., 2009), the intended learning outcomes of interdisciplinary education have been articulated in various ways in the literature, with no universally agreed-upon definition. In our study, we adopted the concept of interdisciplinary understanding as the intended learning outcome of interdisciplinary education. Interdisciplinary understanding is described as:

> The capacity to integrate knowledge and modes of thinking in two or more disciplines or established areas of expertise to produce a cognitive enhancement - such as explaining

> a phenomenon, solving a problem, or creating a product - in ways that would have been impossible or unlikely through single disciplinary means.
> (Boix Mansilla et al., 2000, p. 17)

A review study by Spelt and colleagues (2009) provided guidance on the knowledge and skills components that constitute interdisciplinary understanding. The knowledge component includes knowledge of academic disciplines, knowledge of different disciplinary paradigms, and knowledge of interdisciplinarity. Students require a solid foundation in academic disciplines (i.e., knowledge of academic disciplines) to understand the development of theories and help them step beyond a single discipline. Knowledge of different disciplinary paradigms involves the evaluation and comparison of knowledge across various academic domains. Knowledge of interdisciplinarity refers to the ability to synthesise theories and methodologies from multiple disciplines, enabling a more integrated approach.

Several skills constitute interdisciplinary understanding, namely (critical) reflection, communication, and collaboration skills (Schijf et al., 2023; Spelt et al., 2009). Reflection skills involve the ability to examine one's beliefs, knowledge, and experiences (Kember et al., 2000), and in the context of interdisciplinary education, they help students gain new insights and perspectives. Critical reflection skills facilitate a transformation in an individual's perceptual framework, leading to shifts in perspective and a re-evaluation of deeply held beliefs (Boyd & Fales, 1983; Kember et al., 2000). Communication skills are integral to interdisciplinary understanding, as they foster shared understanding and enable knowledge exchange across disciplinary boundaries (Schijf et al., 2023; Spelt et al., 2009). Additionally, collaboration skills are essential for interdisciplinary understanding, as they enable students to work effectively with individuals from diverse backgrounds, integrating varied knowledge and expertise to achieve common goals or solve complex problems (Schijf et al., 2023).

Students' experiences with interdisciplinary education

Several studies have explored students' perceptions of interdisciplinary versus monodisciplinary education (Baker & Pollard, 2020; Gombrich & Hogan, 2017; Looft & Myers, 2019; Misra et al., 2009; Noy et al., 2017). Research shows that students value the bridges built between academic disciplines in interdisciplinary education, contrasting this with their monodisciplinary experiences, which they feel lack the integration of diverse insights (Baker & Pollard, 2020; Gombrich & Hogan, 2017; Misra et al., 2009; Noy et al., 2017). Students also appreciate the opportunity to consider problems from multiple perspectives (Gombrich & Hogan, 2017; Looft & Myers, 2019), believing it helps them gain insight into their own biases (Baker & Pollard, 2020; Noy et al., 2017) and helps them to recognise how disciplinary backgrounds influence the interpretation of a particular issue by different experts (Looft & Myers, 2019).

While Bachelor's students generally have positive views about interdisciplinary education, they also face challenges. They may struggle to fully grasp the concept of interdisciplinarity and the expectations placed on them (Gero, 2017). Some feel uncertainty about how to contribute their disciplinary knowledge to interdisciplinary discussions (Baker & Pollard, 2020). Additionally, students report a lack of cohesion when disciplinary perspectives are taught separately (Baker &

Pollard, 2020). They also face challenges in collaborating with peers from different disciplines (Noy et al., 2017).

Students' perceived learning outcomes of interdisciplinary education

After having discussed student experiences, this subsection explores what students perceive they have learnt from their participation in interdisciplinary education.

Beginning with knowledge-related outcomes, findings from student interviews suggest that participation in interdisciplinary education enhanced their subject-specific knowledge and the ability to apply this knowledge (Costa et al., 2018). Moreover, students reported that interdisciplinary education fostered a deeper understanding of the differences between their own discipline and other academic disciplines, as well as the ability to recognise diverse disciplinary perspectives (Baker & Pollard, 2020; Brassler & Dettmers, 2017; Noy et al., 2017; Spelt et al., 2017; Taylor, 2018;). Related to this, students mentioned an increased understanding of the interdisciplinary nature of complex issues (Holley, 2015).

When turning to the skills component of interdisciplinary understanding, Costa and colleagues (2018) found that students reported having acquired practical competencies, such as organisational and planning skills as a result of interdisciplinary education. Furthermore, students' noted improvements in collaboration skills (Coogle et al., 2002; Costa et al., 2018). Additionally, students perceived an enhancement in their critical thinking and reflection skills as a result of interdisciplinary education (Brassler & Dettmers, 2017; Haynes & Leonard, 2010).

Guiding students' interdisciplinary learning process

While research has been conducted on students' perceptions of interdisciplinary education, there is a lack of research on the interdisciplinary learning process of Bachelor's students itself. Nevertheless, we found research on the interdisciplinary learning process in the context of PhD education (Graybill et al., 2006; Holley, 2015). This research may offer valuable insights into the learning process of Bachelor's students.

Drawing on their own learning experiences, Graybill and colleagues (2006) describe three stages of interdisciplinary learning. In the first stage (naissance), students from different disciplinary backgrounds join an interdisciplinary programme and become grounded within the disciplines involved in the PhD programme. According to the authors, this is a precondition for combining and integrating the different academic disciplines in subsequent stages. In the second phase (navigation) students learn to balance disciplinary and interdisciplinary contexts. This requires negotiation to accommodate both the depth of a single discipline and the breadth of multiple disciplines in their education and research. In the final phase (maturation), students become capable of explaining their disciplinary contribution to the interdisciplinary field. They demonstrate the importance of disciplinary and interdisciplinary perspectives in their doctoral theses.

Holley (2015) also identified phases in the interdisciplinary learning process of PhD students that align with the findings of Graybill and colleagues (2006): first, students acquire knowledge of the disciplines involved. In the second phase, they integrate knowledge from multiple disciplines and develop multidisciplinary networks. Lastly, students recognise the value of interdisciplinary collaboration and begin participating in such projects.

Method

Research context

This research was conducted within thematic modules (5 ECTS credits, 140 hours) that are taught in the second year of an extracurricular interdisciplinary study programme (45 ECTS credits, 1260 hours). The full programme teaches students to explore societal and scientific issues from multiple perspectives, integrating different academic disciplines to enhance understanding and problem-solving skills. It includes small and broad thematic modules, skills training, an international summer school, and a collaborative project, with interdisciplinarity as a core element. Teaching takes place in small multidisciplinary groups of up to 25 students and is scheduled in the evenings. Appendix 1 provides an overview of the programme. The researchers were not involved in the programme's development, implementation, or teaching. In the first semester of the second year, students choose one of 13 optional broad thematic modules (5 ECTS credits,140 hours, 8 weeks), covering topics such as criminal behaviour, plastic pollution, and global inequality. Each module includes formal assessments (e.g., exam, paper, presentation) that students must pass to earn 5 ECTS credits. This interview study explores only student experiences and perceived learning outcomes within these modules.

Participants

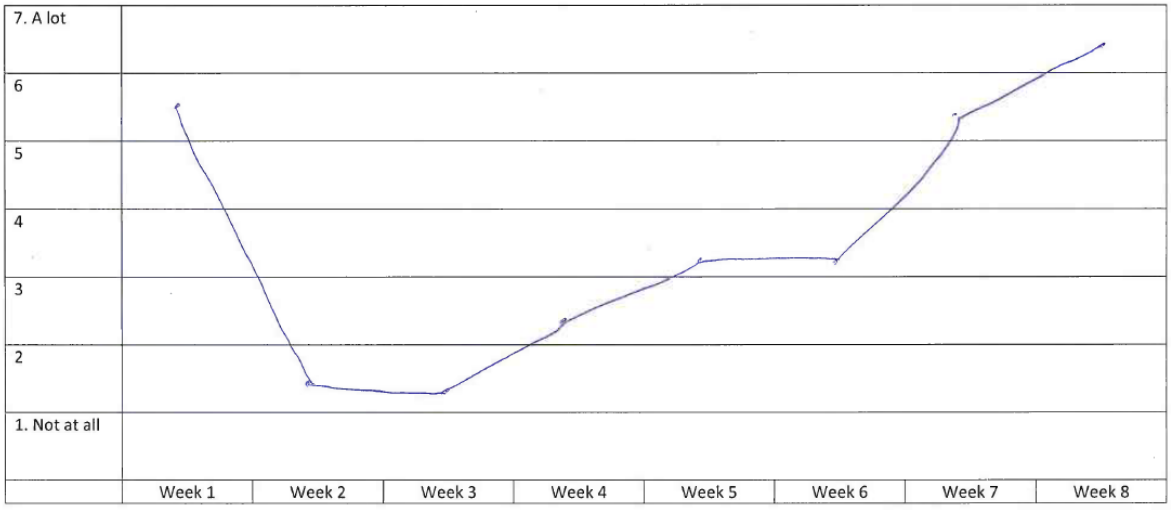
After receiving ethical approval from the Ethics Committee of the first author's department, all students enrolled in the second year of the extracurricular interdisciplinary programme (N = 300) were invited to participate in an interview regarding their learning experience in the module they had just completed at that time. A total of fifteen students agreed to participate in an interview. All participants were informed of the research aim and provided explicit, informed consent. The majority of respondents were women (n = 11), which is consistent with the gender distribution observed in the population. Five students had completed pre-university education in the Netherlands, while the majority of students completed their secondary education in other European countries (n = 9) or outside Europe (n = 1). Most respondents were pursuing a Bachelor's degree programme in the field of Social Sciences (n = 6), followed by students enrolled in a study programme within the Humanities (n = 5) and those pursuing a Bachelor's degree in Science and Engineering (n = 4). The 15 respondents were enrolled in 11 different interdisciplinary modules. Some modules were thus taken by more than one respondent.

Interviewing procedure

The first author conducted individual semi-structured interviews (45 minutes) using an interview guide. With permission, interviews were recorded and transcribed verbatim. Students were asked to draw a storyline representing their perceived levels of challenge and motivation throughout the module. This method, previously used to map student and lecturer experiences (Beijaard, Van Driel, & Verloop, 1999; Scager et al., 2013), involved marking challenge and motivation levels for each week on a blank grid (see Figure 1). The storylines served as conversation starters. Follow-up questions were for instance: "What made week 8 particularly challenging?" and "How was week 8 (high challenge) different from weeks 6 and 7 (low challenge)?" Students were also asked about their perceived learning outcomes, with questions like, "What did you learn in terms of

content?" and "How does this module differ from your monodisciplinary modules?" Since interviewed students participated in 11 different thematic modules, their storylines were not directly compared. Instead, the focus was on identifying moments of high and low challenge and motivation and the factors influencing these fluctuations. These underlying factors were analysed through thematic content analysis.

Figure 1.
Storyline perceived level of motivation during the module



Coding procedure

A thematic content analysis was conducted using inductive and deductive qualitative approaches (Van Staa & Evers, 2010; Van Lanen, 2010; Wilkinson, 2004 as cited in Silverman, 2006). To answer the first research question, we used an inductive approach and mapped student experiences through open coding to identify the factors that challenge and motivate students in their learning experiences. During this process, codes were merged into overarching themes. As an illustration, the themes of “connecting to previous knowledge” and “connecting to practice” both highlight the importance of “making connections”.

For the second research question, we first examined the data from a deductive perspective, using the knowledge and skills components of interdisciplinary understanding as fixed codes for analysis. After that, we adopted an inductive approach to our data analysis and developed new codes. For instance, when examining the code “collaboration skills”, we identified the underlying theme of students' “prior experiences” (i.e., new code) with collaboration and how their perception of working together positively evolved as a result of participating in the module.

Results

Students’ experience: challenges and motivation

Throughout the data analysis, several themes emerged. In this section, we illustrate that students’ perceived levels of challenge were positively influenced by gaining new knowledge, skills and

experiences, collaborating with peers, personal development, and perceived pressure. However, challenges were negatively affected when familiar content was presented, when content was repeated, or when levels were perceived as too high, leading to disengagement.

Regarding perceived levels of motivation, students were positively motivated by learning something new, making connections with prior knowledge or practice, actively participating, and being inspired by their lecturers. Negative motivation was linked to content repetition, feelings of wasted time, and uncertainty about how to connect to the topic. From an organisational perspective, students reported that their motivation was negatively affected by evening scheduling and the extracurricular nature of the module. They sometimes felt more motivated to invest effort into their curricular (monodisciplinary Bachelor's) programme than into the extracurricular module. Factors as learning new content, active participation, and collaboration overlap in influencing both challenge and motivation.

We found that students' exposure to new knowledge and skills is a significant, mostly positive, challenging aspect of their educational experience.

> *"Topics I haven't heard much about before, I find challenging. Because then it is something new."* Sarah, Natural Sciences

A number of students were challenged and motivated by learning research methods and scientific writing techniques from academic disciplines other than their own. Participants found it stimulating to make new connections, such as between the module in the interdisciplinary programme and modules in their regular monodisciplinary Bachelor's programme. It also motivated them to connect the knowledge they learned at university with its practical application in daily life:

> *"He [lecturer] also from the beginning said: 'This is about chemistry, but also a bit about other lessons I want you to take for life'. And it turned out to be just that. So he actually taught us that most of the plastics that are out there are widely recyclable. The problem is not the plastics in itself. It's more the way we treat them and that we don't recycle them properly and stuff like that."* Liam, Humanities

Excessive repetition of content and teaching topics that students were already familiar with were considered a waste of time, and were therefore mentioned as a negative challenge:

> *"Then I thought, 'Now we've discussed three parts of the book, now I kind of believe it'. [...] So then you got into a bit of a rut actually."* Violet, Social Sciences

Some students discussed encountering unfamiliar terminology that had not been introduced by the lecturer, which posed a more negative challenge for them as it made it difficult to become fully engaged with the topic. A few students were hesitant to ask for clarification because they assumed that the terminology was considered part of prior knowledge.

> *"They used terminology that I didn't really know, because I study Economics. He said for example 'neurotransmitter' and didn't explain it. Probably because a lot of students already knew that. But I had no clue what he was talking about."* Emily, Social Sciences

Similarly, when students found it difficult to establish a connection with their Bachelor's programme or were unsure how to apply the knowledge they gained to address social issues, it negatively impacted their learning experience:

> "*I thought they would want us to give a real practical solution. I thought it would be more practice-oriented, but it ended up being very theoretical. [...] It was always like such a waste to have a room full of, you know, motivated and highly educated people. Just to sit and not talk."* Liam, Humanities

Thus, finding a balance between positively challenging students with new, complex knowledge and paying enough attention to their prior knowledge is not an easy task. When the subject matter is too complex, students might disengage and, as a consequence, become unmotivated:

> *"I didn't feel challenged, because I just stopped listening. […]. I mean, I guess I would have felt challenged if I was actually trying to aspire to the goals, so to speak."* James, Natural Sciences

Further examination of teaching methods and the role of the lecturer revealed that students had difficulties working with their peers, particularly when they were assigned to a group by the lecturer rather than being able to choose their own group members. This was due to discomfort in working with unfamiliar individuals whose expectations and study styles did not align with their own. This finding will be discussed further in the next section on perceived learning outcomes.

> *"It was a group, like me, one guy, and one girl. The guy didn't really care of what we were doing. The girl really wanted to work on it. And I was really opposed to working so much on it. Because I just don't have two hours to discuss like the discussion question again. So I told them that I'm not gonna do it."* Hannah, Humanities

The small group teaching design motivated students to actively participate and facilitated interaction between the lecturer and students. Additionally, students appreciated the lecturers' engagement and considered it an important factor in motivating them.

> *"He [lecturer] was great. I can't remember his name, but the chemical engineer. He was very motivated and he pushed everyone to do more work. He just had a very interesting presentation style."* Adam, Social Sciences

Several students mentioned their comfort zones when discussing challenges related to personal development. For example, one student found it difficult to ask very personal questions as part of an assignment, struggling to cross a personal boundary.

> *"When that woman [with a psychiatric disorder] came in, on that trip [to a psychiatric clinic], that was more personally challenging. Because, I mean, I tried to imagine myself in her shoes and it really touches you. So you have to keep strong."* Isabel, Humanities

Moreover, students associated pressure with their perceived levels of challenge and motivation. They felt positively challenged to obtain a high grade and often imposed pressure on themselves. They were also motivated by the perceived expectations of their fellow students, which pushed them to challenge themselves further.

> *"It didn't feel like I was making a good contribution. [...] Then a group member mentioned all kinds of theories and I thought: 'I have heard of them, but I don't remember what they mean'."* Maeve, Social Sciences

Lastly, students often mentioned the extracurricular nature as a challenge to their motivation. The modules were timetabled in the evenings to accommodate the schedules of the 45 different

Bachelor's degree programmes that the students could come from. As a result, students felt tired and less motivated after a full day of lectures in their regular monodisciplinary programme.

> *"I wasn't motivated for this. I think here and there I was really tired as well. Because our classes were late as were most of the modules. I think from 7 to 9 PM".* Adam, Social Sciences

Since students had to divide their attention between their curricular and extracurricular modules, they mainly focused on their curricular Bachelor's modules during examination periods, as these credits count towards their Bachelor's diploma requirements (the grades obtained in the extracurricular programme do not). Although they attended the modules during busy exam periods, students were less motivated to actively engage in extracurricular interdisciplinary education.

> *"It [motivation] kind of went a bit down in the next few weeks, just because I was very busy with the other [curricular] modules. I felt like… I was doing it just to not get a bad grade."* Olivia, Humanities

Students' perceived learning outcomes

We now focus on students' perceived learning outcomes from participating in an extracurricular interdisciplinary module. These findings are organised into two subsections: the perceived knowledge-related learning outcomes (disciplinary knowledge, knowledge of different disciplinary paradigms, and knowledge of interdisciplinarity) and the perceived skills-related learning outcomes (critical reflection, communication, and collaboration skills) of interdisciplinary understanding (Schijf et al., 2023; Spelt et al., 2009).

Perceived knowledge-related outcomes

During the interviews, students were asked to explain what they had learnt in the interdisciplinary module. Many students immediately mentioned the new disciplinary knowledge they had gained in the module, including unfamiliar concepts and theories that are not covered in their monodisciplinary Bachelor's programme:

> *"I learned about how addiction works, more or less. How someone gets addicted. Chemically, what goes on in their brain. And how addiction is not just about drugs and this kind of consumption thing. It's more about psychological effects."* Isabel, Humanities

They also discovered throughout their participation that their monodisciplinary programme provided them with valuable knowledge and insight that they could apply in the interdisciplinary module. They discovered the added value of their own discipline:

> Interviewer: *"What could you use from your regular [i.e. monodisciplinary] studies in this essay?"*
> Isabel (Humanities): *"The political side of things. So arguing whether this was the right thing to do in terms of government wise and how they would even implement this kind of law."*

Students expressed that interdisciplinary modules did not provide a comprehensive overview of an academic discipline. In a monodisciplinary programme, they felt more able to learn in depth

about a specific topic. Reaching this depth was considered more challenging in a broad interdisciplinary module.

> *"It's like only touching the tip of the whole iceberg, I think. I guess classical studies is a whole study, a whole area. And I don't think that one module can provide us even with the basics [of an academic discipline]."* Hannah, Humanities

During the modules, students explored the various approaches that different academic disciplines take towards the same issue. As a result, they highlighted the importance of gaining knowledge of different disciplinary paradigms.

> *"We [psychologists] have a very different idea of what is possible to do in biology than biologists have. We don't even think about 'oh maybe it would be possible to treat that disease'. We [psychologists] definitely want to treat it, but we don't know that they [biologists] are actually already achieving that."* Julia, Social Sciences

Knowledge of interdisciplinarity through the integration of knowledge from multiple academic disciplines into new theories and solutions was not extensively discussed by the participants. Instead, students focused on familiarising themselves with other academic disciplines and comparing insights from these disciplines to their own disciplinary background. Only a few students articulated how their newly acquired knowledge and skills could benefit their own discipline.

> *"I learned about psychology, but also about economic decision-making. Now that I better understand how the brain works, I definitely see it everywhere around me. […] In many ways I can connect it to my own studies. For example, how human decision-making can be influenced by the design of a building. That it affects someone's route."* Violet, Social Science

Perceived skills-related outcomes

After having described perceived learning outcomes related to knowledge, we move on to those related to skills. Students did not discuss their gained reflection skills in isolation. However, in interviews, students reflected on how their knowledge and beliefs relate to those of other participating students and academic disciplines. In the interdisciplinary modules, students learned that individuals from different disciplines may have varying perspectives.

> *"Everyone comes up with different examples and with different answers when asked something. That's funny, you can notice that someone has a different background. [...] You can look at it [i.e., a particular problem] from so many different viewpoints and for me it makes perfect sense to understand a topic in that particular [i.e., in her disciplinary] way."* Violet, Social Sciences

We found that students made trade-offs regarding the relevance of knowledge to the topics they were working on, which is an example of reflection skills. They questioned how they could apply the knowledge gained in the interdisciplinary module to their monodisciplinary Bachelor's curriculum. Examples of this process were illustrated in the previous section. For instance, Julia compared the reflections of psychology and biology students on a particular disease.

As previously discussed, students felt challenged by learning new terminology and adapting to

the language of other academic disciplines. These examples relate to communication skills. Some students were introduced to new scientific writing styles and citation formats across disciplines. Others gave scientific presentations, despite not having received training in presentation skills during their regular monodisciplinary Bachelor's curriculum:

> *"We don't actually have any presentations in psychology. So that was challenging for me, because I barely ever do it."* Adam, Social Sciences

The most frequently mentioned perceived learning outcome was the development of collaboration skills and gaining positive experiences in collaborating. In their previous education, collaboration often led to problems as group members did not strive for the same grades or results:

> *"Because, in secondary school I was often the one doing it anyway. Because: 'We have to do it and I want a high grade.' Everyone else didn't necessarily want that high grade."* Maeve, Social Sciences

Respondents found a potential explanation for the positive collaboration experience in the fact that all students in the programme were high-achieving and had voluntarily opted for the extracurricular programme:

> *"They are quite, how do you call that, not necessarily driven, but ambitious I would call them, universally ambitious. [...] Ambition is definitely something we all have to various degrees in different ways. Ambition and a desire to learn."* Lily, Natural Sciences

Participants also experienced the added value of collaboration that goes beyond dividing paragraphs between them, which is a frequently used strategy for collaboration:

> "*Before that, it [collaboration] was more like the shared doc[ument] and everyone put something in the shared doc."* Liam, Humanities

Students' reflection on perceived interdisciplinary learning outcomes

On a more meta level, students expressed that they did not expect to retain all the perceived interdisciplinary knowledge and skills outcomes. They observed that they would pursue their specific interests more, based on their disciplinary background or personal preferences. One student noted that perceived knowledge gains related to other disciplinary perspectives, which she found less interesting, would tend to fade quickly.

> *"I feel like reading a book that's not my favourite genre, you know. Like I remember it for a couple of days, but then forget it."* Hannah, Natural Sciences

Another student used the metaphor of a trip to a foreign country to describe her learning experience, which we believe effectively captures the interdisciplinary student experience and perceived learning outcomes. Similar to travel, the extracurricular interdisciplinary journey broadens students' horizons, enriching their monodisciplinary Bachelor's degree with new knowledge, skills, and experiences. The interdisciplinary modules offered students unique insights not achievable within monodisciplinary modules.

> *"When I've been on holiday or when I've been on a trip to a country with a different culture… You really come back with a - that sounds a bit floaty - but then you come back like… Wow, that's how I'd never seen it before."* Violet, Social Sciences

Discussion

Our study focused on the interdisciplinary learning experience of Bachelor's students in an extracurricular interdisciplinary module. The study aimed to identify challenging and motivating factors, and students' perceived learning outcomes. Students were positively challenged and motivated by learning and experiencing new theories, teaching methods, and skills. Making connections with previously acquired disciplinary knowledge and practice was stimulating for them. These findings are in line with previous research that demonstrate that students perceive added value in an interdisciplinary approach with regard to acquiring knowledge from other disciplines (Baker & Pollard, 2020; Gombrich & Hogan, 2017; Looft & Myers, 2019; Misra et al., 2009; Noy et al., 2017), connecting and contrasting disciplinary insights, and gaining insight into how perspectives are shaped by individuals' disciplinary backgrounds (Baker & Pollard, 2020; Noy et al., 2017). Students found it challenging to work with students from other disciplines, which is also in line with previous research among Bachelor's students. (Noy et al., 2017).

We found that students' challenge and motivation quickly decreased if there was a lot of repetition or if they failed to make a good connection with pre-existing knowledge. In contrast, active forms of teaching and an enthusiastic lecturer motivated students to go the extra mile, as was also found in previous research on students' experiences with interdisciplinary education (Baker & Pollard, 2020). Challenges also arose from internal and perceived external pressures, including those from themselves, fellow students, and lecturers. This pressure was associated with the students' desire to meet the expectations of others. Previous studies did not address the role of perceived pressure on the learning experience, and our study thus brings a new perspective on students' experiences.

Perceived interdisciplinary learning outcomes were identified based on theories regarding the constitution of interdisciplinary understanding (Schijf et al., 2023; Spelt et al., 2009). In terms of perceived knowledge-related outcomes (knowledge of disciplines, knowledge of different disciplinary paradigms, and knowledge of interdisciplinarity), students highlighted gaining knowledge of disciplines and knowledge of different disciplinary paradigms. Our study found that actual integration of knowledge and skills from multiple disciplines (knowledge of interdisciplinarity) was scarcely discussed by students as a perceived outcome. This raises the question of whether integrating disciplinary perspectives is a realistic goal within a 5 ECTS credits module at the Bachelor's level. Follow-up research exploring phases of acquiring interdisciplinary understanding and developing a phased framework for curriculum development would be valuable. We will return to this in the Practical implications section.

Regarding the skills-related components of interdisciplinary understanding ((critical) reflection, communication, and collaboration skills), students demonstrated reflection skills in their ability to discuss their learning during interviews, but they did not explicitly identify these as perceived outcomes of the module. Communication skills were perceived to have improved, particularly through exposure to new academic terminology. Students also reported gains in their ability to communicate research findings effectively, having been introduced to different writing styles and presentation techniques. In terms of collaboration, some respondents initially expressed discomfort with working in new groups due to past negative experiences. However, they often found the experience to be positive and began to appreciate the value of working in diverse teams.

Notably, while students mentioned improvements in communication and collaboration skills as perceived outcomes, they did not discuss reflection skills as an outcome. This suggests that reflection skills may have been seen as already acquired or were not clearly identified as an outcome of interdisciplinary education. It highlights the importance of explicitly integrating skill development into the curriculum.

When linking Bachelor's students' experiences in our study to the learning process identified among PhD students (naissance, navigation, and maturation phases, as described by Graybill et al., 2006), similarities can be observed. Although learning phases were not explicitly examined in our study, our findings suggest that the focus of Bachelor's students' experiences is on the naissance phase, where they become acquainted with each other and gain knowledge and skills from other disciplines. Some students find this easier than others. For example, if terminology or theories are explained only briefly, students tend to remain in this naissance phase and seek common ground. Students also attempt to navigate between different disciplines (navigation phase), as evidenced by the differences they observe between academic disciplines regarding scientific theories and research methods. However, participants in our study did not yet form an interdisciplinary identity, as PhD students do during the maturation phase. As mentioned before, discrepancy can be attributed to the fact that the students in our study were Bachelor's students and discussed their experiences in one module over 8 weeks, whereas the curriculum in Graybill and colleagues' (2006) article encompassed a 2-year PhD programme. Future longitudinal research into Bachelor's students' learning experiences is recommended.

Limitations and further research

Several limitations and suggestions for further research are worth discussing. Regarding the qualitative method used, it is important to acknowledge the potential limitation posed by the small number of participants and self-selection bias. It is recommended that further investigation into student experiences be conducted using large-scale quantitative methods or by triangulating the interview data with other qualitative methods, such as observational studies.

The extracurricular interdisciplinary programme under study offers several optional modules to students. The participants in our study selected one particular module that aligned with their interests from a total of 13 optional modules. Consequently, the modules taken by the participants were not identical. We propose replicating this study among a group of students all enrolled in the same module, as this would control for certain aspects of the learning experience. Nevertheless, we believe that our study offers valuable insights into students' engagement with interdisciplinary education.

The experiences described are those of students who had recently enrolled in an extracurricular interdisciplinary programme. We expect that their experiences may differ in subsequent semesters. Third-year students might apply lessons learned from earlier interdisciplinary modules to later modules in the programme. This could lead to other perceived learning outcomes, such as a greater perceived ability to integrate perspectives from multiple academic disciplines into new solutions or approaches to scientific and societal challenges. We therefore suggest conducting a follow-up study on the learning process and perceived learning outcomes of students in subsequent years of the interdisciplinary programme.

This study focused on students' experiences and their perceived learning outcomes. To further enrich these findings, it would be valuable to examine the intended learning outcomes in relation to the attained outcomes and complement them with the outcomes as perceived by the students themselves. This approach would identify areas where the teaching-learning process could be improved. Additionally, considering the experiences of the lecturers teaching these modules is crucial. As part of a larger research project, we conducted a study on lecturers' experiences in teaching the 13 modules under study, offering insights into the enacted curriculum (Schijf et al., accepted for publication). The results indicate that lecturers, among other challenges, face difficulties in addressing students' prior knowledge, accommodating student interests, fostering collaboration, and maintaining consistency in interdisciplinary teaching.

Practical implications

The results of our study on student experiences and perceived learning outcomes provide guidance for the design of interdisciplinary modules.

Guiding principle 1: Common grounding

When designing an interdisciplinary learning experience for Bachelor's students, the importance of "common grounding" must be taken into account. During an interdisciplinary module, students encounter unfamiliar academic disciplines, requiring them to familiarise themselves with new terminology, theories, perspectives on scientific and social issues, and research methods. These challenges can be frustrating, especially when teaching does not address assumed prior knowledge.

A clear introductory phase at the start of the module is essential. Students should be supported in understanding new disciplines, and lecturers must connect with their prior knowledge. In our view, this common grounding is crucial for facilitating the interdisciplinary learning process and preventing students from losing interest or failing to make meaningful connections. It is a prerequisite for interdisciplinary learning.

Guiding principle 2: Contrast perspectives

A key theme in the student experience was the differences students observed between their own academic discipline and those disciplines presented in the module. Students noted similarities and differences in knowledge, methodology, and the way issues were discussed, comparing them with the approach taken in their monodisciplinary Bachelor's programmes. Notably, students tended to use their own disciplinary background as a benchmark for comparison, finding it difficult to analyse differences between disciplines they had not encountered before.

A guiding principle derived from these observations is the importance of contrasting disciplinary perspectives in teaching. Particularly at the Bachelor's level, students cannot be expected to automatically connect their own discipline with others. Therefore, active attention should be given to contrasting perspectives. This could be achieved by having students read and discuss articles from two different perspectives or by inviting lecturers from two disciplines to debate a specific issue.

Guiding principle 3: Connect to own discipline

Interdisciplinary understanding, as an intended learning outcome, is defined as the ability of students to integrate knowledge from two or more disciplines to address, for example, a complex issue (Boix Mansilla et al., 2000). Ultimately, in interdisciplinary education, lecturers should strive for this integration. In our interviews with second-year Bachelor's students, it was noticeable that students placed a strong emphasis on their own academic discipline. They used their discipline as a starting point for comparison and, as a perceived learning outcome, mentioned how they could strengthen their own disciplinary competencies with insights from other disciplines encountered in the interdisciplinary module. In our opinion, it is unrealistic to expect a Bachelor's student to fully master interdisciplinary understanding in a single 5 ECTS credits module, and therefore, integration should not be the ultimate goal of the described modules. For Bachelor's students, we believe that connecting insights from other disciplines to their own discipline should be the intention.

Building on the emphasis on how students can connect insights from other disciplines to their own, it is advisable to incorporate reflection questions and assignments that challenge students to actively make these connections. These should encourage students to consider both what they can learn from other disciplines and what added value their own discipline brings to other academic fields. Friendly force students to engage in multidisciplinary groups further encourages them to learn from each other and helps them understand and communicate the added value of their own discipline.

Conclusion

Our study explored the experiences of Bachelor's students in an extracurricular interdisciplinary module and their perceived learning outcomes of such a module. The findings and practical implications presented can guide students on their interdisciplinary learning journey and assist lecturers in preparing students for future challenging roles in science and society.

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Appendix

Schematic overview of the extracurricular programme students follow

The full programme schedule of the extracurricular interdisciplinary programme is shown below. To illustrate, we have also included the students' monodisciplinary Bachelor's programme schedule. Programme elements are explained after the schedule. The optional thematic modules relevant to our study are those scheduled in Year 2, Semester 1 (September–January), and are indicated by bolded text and a grey background.

Study year	**Year 1**		**Year 2**		**Year 3**	
Semester	**Sept – Jan**	**Febr - June**	**Sept – Jan**	**Febr - June**	**Sept – Jan**	**Febr - June**
Monodisciplinary Bachelor's degree programme (180 ECTS credits)	Regular course work Bachelor's degree programme (30 ECTS credits)	Regular course work Bachelor's degree programme (30 ECTS credits)	Regular course work Bachelor's degree programme (30 EC ECTS credits)	Regular course work Bachelor's degree programme (30 ECTS credits)	Regular course work Bachelor's degree programme (30 ECTS credits)	Regular course work Bachelor's degree programme (30 ECTS credits)
Extracurricular interdisciplinary programme (45 ECTS)		Personal development (1 EC)				
		Skills module (2 ECTS credits)	Skills module (2 EC)	Thematic module (5 ECTS credits)	Thematic module (5 ECTS credits)	Thematic module (5 ECTS credits)
		Thematic module (5 ECTS credits)	**Thematic module (5 ECTS credits)**	Summer school + interdisciplinary project (5 ECTS credits)		
			Thematic module (5 ECTS credits)	Thematic module (5 ECTS credits)		

Study component	ECTS	Description
Personal development	1	Students attend several workshops focused on developing academic, personal and professional talents. Workshops are giving in multidisciplinary groups of students.
Skills modules	4	Students pick two Skills modules from a larger offer, e.g., effective teamwork, data visualising, academic writing, debating. Modules are trained in multidisciplinary groups of students.
Thematic modules	35	Students pick thematic modules from a larger offer, e.g., criminal behaviour, plastic pollution and global inequality. Modules are taught in multidisciplinary groups of students.
Summer school + project	5	In a multidisciplinary group, students stay abroad for up to seven days and are introduced to a multi-faceted scientific and/or societal problem. Students and lecturers work on this topic in a subsequent project, where they translate the problem into a future-oriented interdisciplinary vision and approach. Students chose from 13 different summer schools/ projects.