Boundaries and boundary crossing in a multidisciplinary online higher education course on forest bioeconomy

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Abstract
The field of higher education (HE) is characterized by diversity stemming from multiple sources. Diversity results in boundaries that carry the potential to promote personal and professional development for HE students. Boundaries also offer the possibility of learning generic skills and planning and carrying out challenging tasks that require collaborative problem solving in multidisciplinary teams. Drawing upon the theory of boundary crossing, this study aims to identify the kinds of boundaries that HE students experience during a multidisciplinary online course on forest bioeconomy and how they manage these boundaries in terms of boundary crossing while collaboratively solving an ill-defined development challenge set by a working life organization. The data consist of in-depth interviews with student teams (N = 20). The results provide insights into the pedagogical

principles through which students' boundary-crossing processes can be facilitated in HE online learning settings.

Abstract in Finnish

Korkeakoulukentälle ovat ominaisia tieteenalojen hyvin erilaiset tieto- ja taitovaatimukset sekä toimintamallit, mutta toisaalta myös tarve oman tieteenalan rajojen ylittämiseen. Näiden rajojen ylittäminen voi olla opiskelijalle haastavaa, mutta ne tarjoavat myös mahdollisuuden kehittää omaa ammatillista osaamista, oppia geneerisiä taitoja sekä harjaantua ratkaisemaan työelämälle tyypillisiä, monialaista yhteistyötä vaativia tehtäviä. Tässä artikkelissa esiteltävä tutkimus pohjautuu rajojen ylittämistä kuvaavaan teoriaan ja sen tavoitteena oli tunnistaa, millaisia rajoja korkeakouluopiskelijat kokevat monitieteisen, metsäbiotalouteen keskittyvän verkko-opintojakson aikana. Lisäksi selvitettiin, miten opiskelijat pyrkivät hallitsemaan näitä rajoja yhteisöllisen ja työelämälähtöisen ongelmanratkaisuprosessin aikana. Tutkimuksen aineisto koostuu ryhmähaastatteluista, joihin osallistui 20 verkko-opintojaksolle osallistunutta korkeakouluopiskelijaa. Tulokset tarjoavat tietoa siitä, millaisilla pedagogisilla ratkaisuilla erilaisten rajojen ylittämistä voidaan tukea korkeakoulutuksen verkko-opiskelukonteksteissa.

Introduction

Current social and cultural practices in education and work are characterized by specialization, which creates a need to find ways to promote participation and collaboration between individuals and institutions within and across areas of expertise (Tassone et al., 2018). Collaboration and problem solving are also much needed in a complex world that confronts current global challenges, such as climate change and a global pandemic, which cannot be solved with a single area of expertise. Multiple actors representing different professional cultures and fields, as well as the ability to create novel applications of information and technologies, are needed (e.g. Carr & Lesniewska, 2020). Diversity and contradictions work as driving forces for change and development, and learning is a central part of collaboration in such multidisciplinary networks and teams. Those involved need to work with unfamiliar areas of expertise, cultures, habits, roles, and knowledge (Edmondson & Harvey, 2018; Rowe & Zegwaard, 2017) and to learn utilizing such diversity, which can be considered a process of crossing boundaries. Conceptually, a boundary is defined as "a socio-cultural difference leading to discontinuity in action or interaction" (Akkerman & Bakker, 2011, p. 133), and it carries potential for learning through the mechanisms of boundary crossing.

In higher education (HE), boundaries can be found in disciplines' structures (Hannon et al., 2018), collaboration with working life partners (Mavri et al., 2021), and the variety of participating students' socio-demographic and cultural backgrounds (Boulton, 2019; Devlin & Samarawickrema, 2022). Students can benefit from these boundaries by learning in teams characterized by diversity, as this can promote their personal and professional development, multidisciplinary learning, generic skills, and ability to plan and carry out challenging tasks requiring collaborative problem solving (Boulton, 2019; Galvão et al., 2021; Mavri et al., 2021). In terms of employment, interpersonal and social skills are considered especially desirable in working life (Salas Velasco, 2014; Suleman, 2016).

However, engaging HE students in cross-boundary learning is not pedagogically straightforward, particularly if learning takes place in online settings (Dumford & Miller, 2018). Implementing HE teaching in multidisciplinary online settings that foster boundary crossing requires orchestration in terms of pedagogies, collaboration with other teachers, assessment, technologies, content, working methods, and structures (Boulton, 2019; Devlin & Samarawickrema, 2022; Vuojärvi et al., 2019). This study considers boundaries and learning as boundary crossing in online HE in the context of forest bioeconomy. The focus is on students' experiences, and the aim is, first, to determine the kinds of

boundaries that HE students experience during an online multidisciplinary course, and, second, to describe how their learning processes on these boundaries unfold in terms of boundary crossing. The context of the study is a novel online course designed and studied during a larger design-based research (DBR; Anderson & Shattuck, 2012; Wang & Hannafin, 2005) project (Vartiainen et al., 2022; Vuojärvi et al., 2019). The course was open to all students in Finnish HE, and it aimed to promote HE students' learning of generic key competencies that are required in contemporary society, here referred to as 21st-century skills; these are defined as skills related to (1) ways of thinking, (2) ways of working, (3) tools for working, and (4) living in the world (Binkley et al., 2011). During the course, the students worked in multidisciplinary teams to solve an ill-defined development challenge set by a working life organization (a company or a non-governmental organization) representing the area of forest bioeconomy. The conceptual emphasis of the development challenge was on sustainability and well-being.

Theoretical background

Learning in this study is considered through the theory of boundary crossing (Akkerman & Bakker, 2011; Engeström et al., 1995). It is rooted in the sociocultural understanding of learning, according to which learning is part of one's social and historical context and entails the transformation of both the person and the social world (Vygotsky, 1978). In HE, boundaries can be expected because this domain is characterized by diversity, yet with the concurrent aim of enabling students to gain competencies so that they can manage working in cross-boundary working life settings.

The concept of boundary crossing refers to a learning process that can be characterized as a negotiation of meanings. This process is needed to fade the ambiguity of boundaries and foster individuals' interactions across different sites (Akkerman & Bakker, 2011). Central to the idea of boundary crossing is its processual nature; interactions on both sides of the boundary are ongoing. In their review, Akkerman and Bakker (2011) identified four types of learning mechanisms that take place at boundaries:

- *identification*, which means learning about practices by distinguishing their individual identities. This can take place by defining one practice in relation to another or by considering how practices interfere with one another in order to pursue them both.
- *coordination*, which means learning how diverse practices can be engaged in simultaneously and effectively by facilitating communication between practices or perspectives, putting effort into translating different practices to others, crossing different practices repeatedly, establishing rites or rituals, and routinizing (i.e., creating procedures that make coordination an automatic part of practice).
- *reflection*, which means learning to realize and explicate differences between practices. Reflection entails both externalizing one's own understanding and knowledge and consciously and actively pursuing trying to see things from another perspective.
- *transformation*, which refers to the learning process resulting in changes in existing practices or new practices altogether. Transformation starts with confronting the experienced inadequacies or problems in established practices and moves on to creating a hybrid practice, tool, or concept that can cross existing boundaries. At its best, the transformation process entails embedding the hybrid result into practice, routines, or procedures or reinforcing the established practices, as maintaining their uniqueness upholds their relevance and value for each other.

In this study, these boundary-crossing processes are considered by focusing on HE students' experiences of designing a solution to an ill-defined development challenge set by a working life organization. The challenge and related assignments play the role of boundary objects that mediate the negotiation process and help students to cross boundaries (Benn & Martin, 2010). Theoretically, boundary objects are defined as material or conceptual entities that combine individuals, teams, and their contexts (Star, 2010). The key characteristic of a boundary object is that several fields of expertise and individual sociocultural contexts intersect through it. The goal of engaging in dialogue at the

boundary is not to achieve homogeneity and discard diversity but to create continuity between sociocultural worlds.

Previous studies have identified pedagogical success factors that facilitate learning in cross-boundary online settings in the HE context. These include carefully introducing and using multiple types of digital technologies in a pedagogically meaningful way (Boulton, 2019), including stakeholder collaboration in pedagogical design (Benn & Martin, 2010; Vartiainen et al., 2022), designing effective facilitation procedures throughout the online course (Vuojärvi et al., 2019), providing an arena for students to share their existing values, knowledge, and expertise, using effective feedback practices during the process and promoting shared regulation strategies in student teams (Vartiainen et al., 2022), and utilizing authentic assessment methods as resources for learning and iterative development of students' work (Devlin & Samarawickrema, 2022).

As boundaries are defined as sociocultural differences creating discontinuity, and it is individuals or groups of people who encounter this discontinuity, focusing in this study on students' experiences is considered important. Understanding the kinds of boundaries that students encounter in a multidisciplinary online course and through what kinds of learning processes they cross these boundaries during the collaborative solving of a working life development challenge is vital to develop pedagogy that facilitates boundary crossing in online HE settings. This study aims to answer the following research questions:

(1) What kinds of experiences of boundaries can be identified in students' narratives describing their experiences from an online HE course on forest bioeconomy?
(2) In terms of boundary crossing, through what kinds of mechanisms do students manage the encountered boundaries during the online course?

Methods

The educational context

The framing of the present study is a multidisciplinary online course titled *Collaborative Problem Solving in Multidisciplinary Networks* (five European Credit Transfer System credits). The course aims to promote HE students' learning of 21st-century skills by working in cross-boundary teams in the context of forest bioeconomy. The conceptual focus of the course is sustainability and well-being. In the course design, sustainability is defined as an "underlying pattern of health, resilience, and adaptability that maintains this planet in a condition where life as a whole can flourish" (Wahl, 2019, p. 241). Well-being is considered from a subjective perspective (Hascher, 2008) as a balance between psychological, social, and physical challenges and resources (Dodge et al., 2010).

The course was developed as part of a DBR project carried out as a collaborative effort of teachers and researchers from multiple fields of expertise (Anderson & Shattuck, 2012; Collins et al., 2004; Wang & Hannafin, 2005) from the University of Lapland, University of Eastern Finland, Karelia University of Applied Sciences and National Resources Institute Finland. In accordance with the principles of DBR (Wang & Hannafin, 2005), the research and development of the course were structured as two iterative research cycles. These cycles included the phases of 1) designing the content and pedagogy of the course, 2) implementing the online course and collecting research data, and 3) analyzing the collected data and refining the course design. The initial version of the course was designed, implemented, and studied in 2019. The focus of the study concerning the initial course version was on how 21st-century skills manifested in students' experiences from the course; the results were reported earlier (Vuojärvi et al., 2019). This article presents the second DBR cycle, which is the process of refining the course design based on the results gained from the first implementation, testing the refined course, and analyzing it. As DBR aims to develop both knowledge and practice (Anderson & Shattuck, 2012; Collins et al., 2004), the study aims to gain theoretical knowledge of boundaries and boundary crossing practices and use this information on the practical level for pedagogical development. The initial course

implementation included both blended and online course options, but because of the COVID19-pandemic at the time of implementing the course for the second time from May 2020 to August 2020, only the online course option was redesigned.

The 11-week course was structured to three phases for both the first and second course implementations, but some pedagogical refinements were made on the basis of the results from the first DBR cycle (Vuojärvi et al., 2019). A Moodle-based DigiCampus learning management system (LMS) was used as the course platform, and the students used Microsoft Teams for real-time interaction with one another and the stakeholders. They were also free to use any other digital tools during the course. The course started with an *introduction phase*, when the students individually completed preparatory assignments that provided them with an overview of the field of forest bioeconomy and the concepts of sustainability and well-being. The students introduced themselves to one another by providing listings of one's main subject, expertise, and special interests. The second phase and the core of the course was *the development challenge phase*, which engaged the students in solving an ill-defined development challenge in cross-boundary teams that the teachers formulated. The teams' tasks were to create a solution to the challenge and pitch it on a video. During the first course implementation, the teams designed the challenges as part of their course activities, but in the second course implementation, the challenges were set by working life organizations from the field of forest bioeconomy. The involvement of working life stakeholders was considered a meaningful way to strengthen the connection with students' future work contexts and foster the authenticity of the learning experience. The aim of the development challenge phase was to create a common understanding of the nature and focus of the problem and to design a solution for it. The team members' approaches to the challenge were based on their individual personal histories and knowledge rooted in their disciplines. Organizations' representatives were available for the students to discuss the development challenge and help in defining it. The initial course design did not include assessment points during the development challenge phase; however, the role of assessment was strengthened for the second course implementation to monitor teams' progress on the course and provide feedback from peers, teachers, and organizations, which would help them finalize their assignments. The third phase of the course was *assessment*, during which the teams' work was evaluated. In the first course implementation, feedback was provided by the participating teachers, whereas in the second course implementation, it was also provided by the stakeholder organizations. The students completed peer- and self-assessments at the end of the course.

Data and analysis methods

The data collection was carried out through in-depth group interviews performed during the assessment phase of the course. As the research context was in Finland, the guidelines for the responsible conduct of research and the set of ethical guidelines drawn up by the Finnish National Board on Research Integrity TENK[1] were followed. The research design did not include elements that would have required an ethical review. The students were asked for an informed consent to participate in the study, a permission to record the interviews and use them as research data.

Table 1 presents a summary of the participants and the collected data. Throughout this article, the students were referred to with pseudonyms to protect their identities.

INSERT TABLE 1 HERE

Altogether, seven in-depth group interviews were carried out in August 2020, and all but one of the 21 students participated in them. As the interviews were conducted with teams and not with individual students, the narratives were co-constructed through interactions, distanced from the happenings they described, and represented meanings that reached beyond an individual student (Squire, 2013). The interviews were done online using Microsoft Teams software, and they were recorded to obtain a full aural record of the participants' stories.

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[1] https://tenk.fi/en/advice-and-materials/guidelines-ethical-review-human-sciences#4

During the interviews, the teams recalled and reflected on their experiences during the course. The interviews were semi-structured, and the themes covered the entire online course from beginning to end. The students were first asked about their backgrounds and motivations for enrolling in the course. After that, the students were asked to reflect on their thoughts and experiences regarding the individual assignments during the three phases of the course, the collaboration and communication within their teams, the tools and resources that were used, and the meanings they gleaned from the course activities. The students were encouraged to elaborate on their responses in order to increase the validity of the data. To strengthen data reliability, the first author was responsible for carrying out the interviews, and other researchers listened to and followed the interview to ensure that the questions were presented in the same way during each interview, and posed additional questions as needed (Gray, 2014). The interviews were transcribed verbatim by a professional transcription service and checked for accuracy. In total, the transcribed interview data included 32,149 words.

The students' narratives were analyzed thematically (Terry et al., 2017). The interview data were coded deductively according to a coding scheme spanning the students' experiences of boundaries and descriptions reflecting boundary-crossing learning mechanisms (i.e., existing theoretical concepts and the research questions provided a foundation from which to approach the data; Terry et al., 2017). The transcribed data were first read several times to gain an overall understanding of them and promote familiarity with them. Second, the data were coded using initial codes to mark text passages related to the research questions. Third, data extracts with the same code were assembled, the organized data extracts were read, and preliminary and sub-themes were created. Finally, these themes were reviewed and clarified, and it was ensured that each theme contributed to answering the research questions. It should be noted here that, although the analysis process is presented in linear form, practicing thematic analysis means moving back and forth during the process (Squire, 2013; Terry et al., 2017). The analysis process was conducted by the first author and other researchers involved in the study, who acted as critical friends (Squire, 2013). The qualitative data analysis software NVivo (version 12 Pro) was used for the analysis.

Results

The results of the thematic analysis of the students' narratives are presented in the following sections. Quotations from the interviews are provided to clarify the analyses and interpretations. As the interviews were conducted in Finnish, the quotes were translated into English by the authors.

Identifying the experienced boundaries

The first research question focused on the boundaries that the students experienced during the online course. From the thematic analysis, three types of boundaries were identified in the data.

Boundaries between one's own knowledge and skills and the course content. As the course was open to HE students from all fields, the content and concepts of the course were new to most of the students. Those with no background in forest bioeconomy had to enter an entirely new field, but as the focus of the course was well-being and sustainable development, the wide array of concepts and phenomena involved also offered something new to those students with earlier knowledge in the field. The students who were familiar with forest bioeconomy experienced boundaries in combining bioeconomy perspectives with, for example, those of well-being in designing the solution to the development challenge.

> *I am an environmental designer, and I graduated from a sustainable development degree program; thus, sustainability and forest bioeconomy are concepts that are familiar to me, but well-being … maybe somehow but not on the same level.* [...] *I wanted to learn how to combine sustainability with well-being.* (a1)

Some students felt that they did not have sufficient skills for creative production or problem solving or the political insight needed to navigate the development challenge. The ill-defined development

challenge was perceived to be difficult to approach because the students had to negotiate with one another and with the organization that provided the challenge to create a plan of how to solve it.

> *Well, at first, upon reading them* [the development challenges], *I felt that these are all enormous challenges, that each challenge requires a lot of creativity and … well, exactly, that ability to solve problems.* (b1)

Working as a team and managing the operations, timetables, workload, and interactions within the team and with the organization seemed to be challenging to some of the students. As this was an online course, and the students were not located in the same place, some students had to learn new teamwork skills, particularly those related to online teamwork.

> *[...] somehow, I still come from an analogic world, so all these digital things are out of my comfort zone [...] there was quite a lot of all kinds of adjustments plus, at times, I was in the wilderness and not always reachable, so I owe a big thanks to my colleagues in the South for keeping track and keeping me in tighter control at times when it seemed that the guy in the North gets loose too much.* (b4)

Boundaries between existing studying habits and the pedagogical arrangement of the course. According to some students, the use of several digital tools caused confusion and difficulties in managing interaction and information. Implementing the course online and emphasizing the students' independent work individually and in teams seemed to create boundaries between the students and the teachers, as the students experienced difficulties in finding out which teacher to contact and what their area of expertise was. Although the course was organized in three phases, and the students' work was facilitated through written instructions, the clarification of which was done by the teachers, for example, via email, the course structure seemed fractured and difficult to follow. The course started with a preparatory phase that the students completed individually before the teamwork phase started, but some students also hoped for a chance to meet with other students at the beginning of the preparatory phase of the course.

> *It started bothering me that the information started to scatter; all these tasks started to scatter a bit, and these deadlines were a bit here and there, so it was difficult to hold things together. DigiCampus was new to me, and we had to use Teams, so it was a bit too scattered for me.* (a4)

> *We would have needed some help at the point of submitting the first version of the report, but we didn't ask for teachers' guidance. Somehow, it was quite vague for us what kinds of expertise would have been available to support solving the development challenge.* (b6).

Boundaries between different life roles. According to the students, they experienced boundaries in managing different areas of their everyday lives. Mostly, these challenges seemed to be related to multiple engagements; many of the students had families, and the course took place during summertime, so they were occasionally traveling with family members. Some students also had summer jobs along with their studies. Coordinating these roles with course responsibilities was experienced as troublesome at times.

> *It was really challenging to combine it* [the course] *with work and taking care of four children.* (c1)

> *I see the message when I'm at work, but I can't focus on it just yet. Then, I forget it and remember it after two days, like damn, I had to respond to it.* (a2)

The processes of boundary crossing

Identification

The first boundary-crossing learning mechanism—identification—occurred throughout the course when the students considered their own fields of study and their working methods in relation to those of the other students and the course content and concepts. For some students, this process of identification came about in their descriptions of their motivations to enroll and study in the course in the first place, as can be seen in the following quotes from the data:

> *I was intrigued by this course, as it's so different. It differs a lot from what I mainly study, both in terms of working methods and content.* (b1)

> *The development challenge assignments were all interesting, but for me, this one felt like the most challenging one. At first, I felt very sure that I wouldn't choose to solve the one that we did, but for me, that was a sign that it was actually something I needed, so that was why I chose it.* (b3)

As the course proceeded and the students moved on from the preliminary tasks of the introductory phase to the development challenge phase, identification was triggered particularly by the development challenge. The students encountered and reconstructed the boundaries, for example, between their fields of study and their working methods. They had to identify their areas of expertise, acknowledge gaps in relation to the challenge, and determine how they could contribute to the joint effort, as the following students described:

> a4: *I think* [b4] *has the strongest skills and knowledge concerning bioeconomy and sustainability; it was such a relief to have someone like that in our team…*
> b4: *Yes, but we would've been lost without* [c4]. *At the point when there were just the two of us in the team, we realized that neither me nor* [a4] *have competencies in economy; we need someone who understands liquidity flows, so luckily,* [c4] *could join us and fill that knowledge gap.*

The identification process afforded the students the possibility to renew and reconstruct their sense of expertise that is emerging and developing throughout their years of HE studies as they gain other experiences, as one engineering student described:

> *As I'm an engineering student and have been with other engineering students for two years, my mindset is fixed on trying to logically decide and justify decisions on the basis of available resources and effectiveness. But that's not always the best way in real life, and that's what I learned from this—compromising and focusing on the bigger picture, which is most important.* (b6)

Coordination

The second learning mechanism—coordination—occurred at both the individual and team levels. Individual-level coordination was especially related to managing multiple life roles and coordinating duties related to working, taking care of a family, and studying. Team-level coordination was particularly emphasized during the development challenge phase, which required the teams to collaborate as multidisciplinary teams, coordinating their actions simultaneously at the individual and team levels. As the development challenges were open and ill defined, interaction was first needed to define them in more detail and determine how each team member's expertise could be used in solving the challenge. Once the teams reached an agreement on the content of the solution within the team, they had to negotiate the timetables and working methods. The students used various digital tools and shared working methods to generate connections between different life contexts. In addition to using DigiCampus LMS and MS Teams, they also utilized, for example, WhatsApp and Google Drive, to support coordination. Some teams set a clear structure of procedures from the start and negotiated how the workload could be divided. This planning helped these teams get started and proceed smoothly with their development challenge assignments. Some of the teams started working on the development

challenge without a structured plan, and this lack of understanding of the work plan and work division seemed to cause challenges, particularly at the beginning of the work.

> c3: *Actually, we had quite a clear plan for the division of work. We had questions for each of us to get answers to, and we allocated them according to each other's expertise. So that was transparent, at least in my experience.*
> a3: *Yes, it was really easy to proceed with the plan. I think it was also evident in our solution to the development challenge. Everyone's duties came from their own areas of expertise. [b3] was really good at providing forest owners' perspectives and emphasizing the forestry side of things. I focused more on health topics and on finding out what we could actually do with products we gather from the forest. [c3] handled income and calculated finances and such. So, it turned out to be quite a holistic package in which each of us could use their own expertise.*
>
> c2: *I think we had quite a lot of confusion; perhaps we could've properly discussed the division of labor or written down who's doing what. There should've been more interaction.*
> a2: *We did agree already at the start who's going to do what, but perhaps our discussions should've been about ensuring that each of us would do their part.*
> b2: *Yes, and if there would be something that's not clear, it would be a good idea to ask because one can't always explain all things. After all, we're ... we've never seen one another and don't know one another personally, and sometimes, it may be that some words or expressions mean something else to others. So there's this challenge that we don't know one another.*
> c2: *And I think that this MS Teams has had an influence; we had to do everything online, and I think it's a lot different than, for example, sitting down and talking about it.*

Coordination was also needed in relation to the stakeholder organizations' representatives, who assigned the challenge. The intensity of the collaboration with stakeholders varied between teams. Some teams were active in asking for feedback and the stakeholders' input in the process, whereas some were not as active and relied more on their own original ideas. In teams whose stakeholders were closely involved, the feedback sessions particularly helped the students coordinate their processes and directions and improve their solutions' contextual quality.

> *They guided us in the right direction. We had a good basic idea, but they encouraged us to take the first step toward a more finalized solution. We needed a bit of assurance from them to ensure that the solution matched their ideas and that it would be a functional system to continue working on.* (c4)

Reflection

The third learning mechanism—reflection—came about in the students' descriptions of realizing and explicating differences between, for example, team members' knowledge and working methods, and their descriptions of aiming to learn something new about one's own and others' practices. As the course was multidisciplinary and the themes of forest bioeconomy, well-being, and sustainable development were not familiar to all the participating students, the introductory phase of the course was needed to present the students with various kinds of materials and assignments that introduced the central concepts and themes to them. The aim was to mitigate differences in the students' knowledge and provide them with conceptual tools to be used in communication. According to the students' experiences, the introductory assignments helped them reflect on and widen their knowledge.

> *Yes, I think they helped a lot and also somehow helped me compare my current understanding with my previous understanding; there's a difference. I learned quite a lot of new things and had more of those eureka moments with things that I had only some knowledge of before.* (c7)

From individual students' perspectives, collaboration within a multidisciplinary team and with a working life organization afforded them possibilities to become aware of the differences between the knowledge they learn through their studies and how it is realized in working life.

> *In our team, there were members from several fields and from different age groups. This enabled us to compare perspectives and hear about views other than those that I usually encounter. (b6)*

At the team level, the process of solving the development challenge provided the students with an opportunity to reflect upon the differences between team members' knowledge of forest bioeconomy, sustainability, and well-being and to identify how different disciplines or fields of expertise approach these phenomena.

> a5: *I started to understand the multifacetedness of sustainable development and all its areas and aspects. Perhaps I understood only the economic aspects of it before, and this made me see that there's a whole lot more related it, for example, in terms of its social aspect.*
> c5: *And I got to think about sustainable development from the micro perspective. I've dealt with these issues before on a bigger scale, such as from large state-owned companies' perspectives or through large-scale business affairs ... But what it means for an individual or an individual forest owner in their everyday lives, that was new.*

Transformation

In this study, the fourth learning mechanism—transformation—meant that the students had to confront and reconsider their existing knowledge and practices to create a shared understanding of the problem and solve it. Transformation can also be seen at the level of individual learning. The students perceived sustainability, well-being, and forest bioeconomy as complex fields that require constant learning and questioning of their own understanding and knowledge.

> *This* [sustainability] *is such a complex question. There are good goals, but then you notice yourself asking whether they're really achievable in this system. Are we just doing some greenwash? Are these the things that can actually happen, and what makes the future better? [...] The topic is interesting, and I like to look into it and discuss it with others. Somehow, it introduced new perspectives for me. (b4)*

The students perceived their individual learning to be beneficial for their work in the multidisciplinary team and working in cross-boundary settings facilitated their learning of their generic skills. During team processes, the students searched for ways to combine content and working methods from other fields into something new, providing added value to their team while maintaining their unique expertise in their own field.

> *I think you're never "ready" in terms of teamwork competence. Every team is so different, and you always have to start from the beginning. This was a very good experience—having students from different places on the same team and working toward completing a joint project. Something like this is quite rare. I think you end up circling with the same university people and attending your own classes. It's good to jump outside every once in a while. (c4)*

For some students, the course provided an opportunity to transform their future orientation as experts in their own field, as the following student described:

> *I'm currently studying for a bachelor's degree in social services, and these studies have widened my horizon concerning future work possibilities. I gained a lot of tools needed to progress in this field. (b3)*

Working and engaging in a dialogue with working life organizations enriched the students' perspectives of the challenges that the organizations face in their everyday lives. The course took place during spring 2020, which was the start of the global COVID19-pandemic, and social restrictions ended, for example, tourism in Northern Finland, where tourism is a central livelihood.

I also got some perspective on what's going on in the world right now and what concrete effects this situation has on companies. It was quite eye opening to see what kinds of things, for example, tourism companies, are dealing with. People are gone, and companies don't know what to do and how to make a living. It was awakening and made me think about it on a general level. (b6)

Discussion and conclusions

The aim of the present study was to reveal the boundaries that HE students encountered and the boundary-crossing processes that they experienced during an online course. This course focused on teaching generic skills through collaborative resolution of an ill-defined development challenge set by a working life organization in the context of forest bioeconomy. The identified boundaries and learning mechanisms are summarized in Figure 1.

INSERT FIGURE 1 HERE

Following the dual goal of DBR (Collins et al., 2004; Wang & Hannafin, 2005), the results can be discussed from the theoretical and practical aspects. As boundaries are considered possibilities for learning and are therefore vital (Akkerman & Bakker, 2011), the aim of identifying them is not to find ways to get rid of them. Instead, this information can be used at the theoretical level to understand the concept from the students' perspectives in HE settings and at the practical level to design pedagogical practices that facilitate students' process of crossing boundaries in such a way that they are not experienced as obstacles to learning. In the course under study, diversity was enhanced by formulating multidisciplinary student teams and including collaboration with stakeholders in the pedagogical design.

It seems that HE is still quite discipline oriented, and students spend their time with others studying in the same degree programs and focusing on themes relevant to their discipline. However, strong disciplinary boundaries can later complicate students' learning to deal with profoundly complex phenomena and problems (Edwards et al., 2019). HE students need opportunities to strengthen their generic skills and learn how to maintain an open and reflexive mind in contexts characterized by contradictions, complexity, and diversity (Bruno & Dell'Aversana, 2018). Current development initiatives, for example, at the national level of Finnish HE, aim toward more flexible and continuous HE to enable the development of pedagogy and the renewal of HE institutions (Ministry of Education and Culture, 2022). For HE students, this means the possibility of constituting their degrees flexibly of studies provided by several HE institutions. Maximizing these flexible learning opportunities requires the ability to adjust to different kinds of content, concepts, and institutional and disciplinary teaching and learning practices and working methods in different kinds of learning contexts. The results suggest facilitating students' learning in terms of both content and the pedagogies applied in teaching. Additionally, as the number of nontraditional students (i.e., with family or work duties along with their studies) continues to increase (Remenick, 2019), there is a need to provide support in organizing and managing students' studies effectively (Eriksson et al., 2014).

The teams' descriptions of their processes of learning and designing solutions to ill-defined development challenges provided insights into how the teams navigated and managed boundaries in terms of boundary crossing (Akkerman & Bakker, 2011). Each student's and team's experience and path during the course was unique, although analyzing the teams' narratives through a boundary-crossing framework enabled determining some common practices of identification, coordination, reflection, and transformation. Team members seemed to be the resources for individual students when approaching the task of solving ill-defined development challenges. Their teachers' help, however, was not asked, even though the students were encouraged to do so. The students' interactions with the working life organizations were guided through assignments. The activities included organizing a meeting prior to designing the solution, and feedback sessions during and after the process of designing the solution. This kind of structure seems to foster the students' learning from the experience of

collaborating with working life stakeholders (Rowe & Zegwaard, 2017). Organizations' possibilities of getting involved in the course varied, and the results suggest closely facilitating the practices of stakeholders when they are included in multidisciplinary HE learning settings.

The results also shed light on assessment in HE. In the present case, the students were assessed on the basis of their reflective reports on their solutions and the video pitch at the end of the course. They assessed their own and their peers' performance in the course. The feedback discussion in the middle of the development challenge phase also provided a point for reflective assessment suggested in research literature concerning HE (Devlin & Samarawickrema, 2022; Winchester-Seeto & Rowe, 2017). However, all of these focused on the conceptual side of learning. The results suggest developing the assessment practices of future course implementations to include also the identification, verbalizing, and reflection of the boundaries encountered during the learning processes in terms of the practices and all the things affecting such practices, such as diversity. Communicating and reflecting the encountered boundaries could help students to gain the full learning potential of the boundaries (Oonk et al., 2022; Dumford & Miller, 2018) and provide an arena for learning also at the team and course levels. From the teachers' perspective, such reflection could reveal important knowledge concerning students' progress as in online settings it can be challenging to follow students' learning process.

This study is limited to one HE online course, although there is a longer research-based development process behind it. DBR has been criticized for its inherent risk of researcher-led research designs that have no real connection with practice (Anderson & Shattuck, 2012). The present study aimed to minimize this risk through close collaboration between researchers, teachers, and stakeholders. Students' perspectives were involved in the development through feedback and research results from the first course implementation. It can be argued that the researchers' connections with the universities organizing the course can compromise the reliability of the study, but it can also be perceived as a strength because a social and cultural understanding of the context provides the basis for development and research, as well as for deep familiarization with the central concepts and with existing empirical research. Altogether, this strengthens the theoretical triangulation of the study. The data were collected and analyzed through collaborative efforts emphasizing the multiple perspectives in the conclusions. The data from the reflective thematic interviews do not provide access to the actual meaning-making and negotiation processes that the students and teams engaged in during the course. This would require more ethnographic research settings, requiring a heavy investment in researchers' time resources and presence in team activities throughout the course. In such settings, however, researchers' presence might affect the constitution of the data, and their authenticity could be questioned. Similar methodological challenges and the need for methodological development have been identified before (Vartiainen et al., 2022). The present study focuses only on students' perspectives, and the role of others involved in the course and their practices merit further research to gain a more in-depth understanding of boundary-crossing processes (Akkerman & Bakker, 2011).

The role of HE in addressing current global challenges has been emphasized lately, and preparing students to work in a complex and rapidly changing working life has been considered important (Edmondson & Harvey, 2018). The field of HE itself has had to respond to the major and rapid changes and challenges caused by the COVID-19 epidemic. Now, HE is facing the post-pandemic era, which has raised topical discussions concerning future educational strategies and policies (Watermeyer, Crick, Knight, & Goodall, 2020). It seems that, along with structural development, more fine-tuned ways of using digital technologies in HE are needed. This study contributed to such discussions by focusing on the development, implementation, and analysis of a multidisciplinary online course and the pedagogical practices through which the development of HE students' generic skills in online settings can be promoted.

Declaration of interest statement
No potential conflict of interest(s) was reported by the authors.

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Table 1. Summary of the participants' data and the interview data

Teams and team members' disciplines	Interview length	Transcription length (words)
Team 1 students a1 Environmental Politics (U) b1 Law (U) c1 Education (U)	42:37	3,934
Team 2 students a2 Home Economics (U) b2 Chemistry (U) c2 Law (U)	49:55	5,660
Team3 students a3 Education (U) b3 Social Services (UAS) c3 Law (U)	34:59	3,490
Team 4 students a4Forestry (U) b4 Education (U) c4 Chemistry (U)	56:21	4,844
Team 5 students a5 Biomedicine (U) b5 Forestry (U) c5 Business (UAS)	50:07	5,173
Team 6 students a6 International Business (UAS) b6 Electronics (UAS) c6 Environmental Politics (U)	01:01:29	5,994
Team 7 students a7 Forestry (U, not present in interview) b7 Social and Economic Geography (U) c7 Information Science (U)	28:40	3054

EXPERIENCED BOUNDARIES

**One's own knowledge and skills —
The course contents**
- Unfamiliar course content, ill-
  defined development challenge
- Lack of creativity, political insight,
  or problem-solving skills
- Challenges in time management or
  online teamwork
- Deficiencies in teamwork skills

**Existing studying habits —
Course's pedagogical arrangements**
- Confusion from the variety of digital
  tools available
- Incidental interactions with teachers
- Challenging course structure
- Lack of face-to-face meetings

Different life roles
- Working along with studies
- Having family duties along
  with studies

BOUNDARY CROSSING MECHANISMS

Identification
- Considering one's own field of study and working methods in relation to those
  of others and to the content and concepts of the course
- Identifying areas of expertise, acknowledging gaps in it in relation to the
  challenge, and finding out ways to contribute to the joint effort
- Renewing and reconstructing one's sense of expertise

Coordination
- Coordinating actions at the individual and team levels
- Coordination in relation to stakeholders
- Coordination in relation to ways of working and tools for working

Reflection
- Explicating differences between team members' knowledge and working
  methods, aiming to learn about one's own and others' practices
- Reflecting on existing knowledge in terms of course content/phenomena
- Becoming aware of the differences in how learned knowledge is realized in
  working life

Transformation
- Reconsidering existing knowledge and practices when creating a shared
  understanding of the problem and solving it
- Creating ways to combine content and working methods
- Orientating to act as an expert of their own field
- Gaining perspectives of the challenges that working life organizations face in
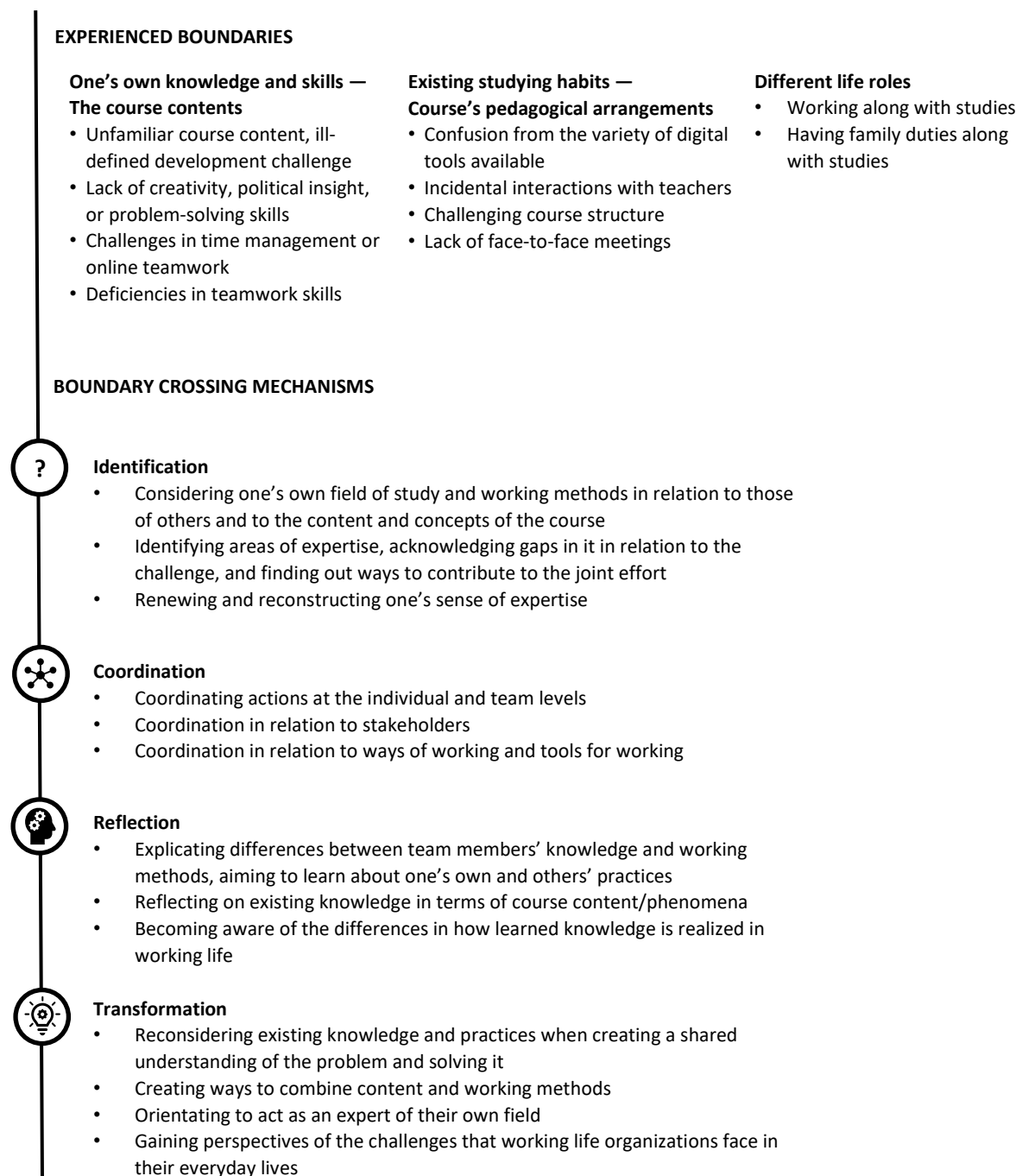 their everyday lives

Figure 1. Summary of the results

Figure captions

Figure 1. Summary of the results