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Cross-Boundary Collaboration and Problem-Solving to Promote 21st Century Skills – Students' Experiences

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Abstract. This study is part of an ongoing design-based research initiative, during which a new course on forest bioeconomics was designed and implemented in higher education context. The pedagogy of the new course was informed by the framework of 21st century skills, ideas of collaborative problem-solving and knowledge building, cross-boundary teaming, and online and blended learning. During the implementation of the pilot course, in-depth group interview data were collected and WhatsApp discussion threads were used as supplementary data. Participants included students (n=18) from Finnish universities and universities of applied sciences who enrolled in and completed the course. The data were analyzed qualitatively with the aim of finding out how 21st century skills were manifested in students' experiences of collaborative problem-solving in cross-boundary teams in blended or online learning settings. It was also considered, if there were differences in the experiences of students from blended and online course options. The results of the qualitative analysis provide multiple implications for course development in upcoming design-based research cycles.

Keywords: 21st century skills; design-based research; higher education; pedagogical development; cross-boundary teams

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Introduction

In Learning Compass 2030, the Organisation for Economic Co-operation and Development (OECD, 2018) suggests some key principles and guidelines for future education systems. These principles direct the development of learning environments and pedagogies intended to promote for example students' creativity, critical thinking, responsibility, resilience, and collaboration (OECD, 2018). From this perspective, learning environments are understood as being more than mere technical constructs or tools that can be defined by a list of characteristics; instead, they are dynamic entities formed through the design of pedagogies that enable students to become active agents in their learning, work on challenging and complex problems that are authentic and interrelated, engage in deep thinking and reflection, collaborate with various stakeholders and learn to use digital technology in meaningful ways (Laurillard, 2012; Vuojärvi, 2013). Through careful design, learning environments and pedagogies can help to build students' contextual knowledge and skills as well as the more generic key competencies that are required in contemporary society, which are often referred to as 21st century skills (Scardamalia, Bransford, Kozma, & Quellmalz, 2011).

There is no consensus on the definition of 21st century skills in existing literature, but several frameworks for defining these skills have been proposed by governmental, academic, business and non-profit organizations (e.g. American Association of Colleges and Universities, 2007; European Union, 2006; International Society for Technology in Education, 2007; Metiri Group, 2003; OECD, 2005; Partnership for 21st Century Skills, 2019). These frameworks are diverse and emphasize different skills, but at their core they share some similarities, based on which one can synthesize a general list of 21st century skills (e.g. Binkley et al., 2012, Dede, 2010; Kereluik, Mishra, Fahnoe, & Terry, 2013; Mishra & Kereluik, 2011).

This study considers the 21st century skills in higher education context and is a part of the first cycle of an ongoing design-based research (DBR) effort (Design-Based Research Collective, 2003; Wang & Hannafin, 2005) during which blended and online versions of a new inter-university course on forest bioeconomics were designed and tested in summer 2019. The aim of this study is to bring out students' experiences from the course that was designed with an overall aim to promote students' 21st century skills through collaborative problem-solving in cross-boundary teams in blended and online learning settings. The focus of analysis is on how the 21st century skills are manifested in students' experiences. As the DBR process is continuing with refining the course's pedagogical design on the basis of the results from this study and implementing the course again, it was considered critical at this point to learn from students' lived experiences during the course. This way students' perspectives can be considered in pedagogical design instead of relying only on teachers' and researchers' views (Cook-Sather & Luz, 2014; Grion, 2014; Hämäläinen, Kiili, & Smith, 2017; Rasi & Vuojärvi, 2018).

The study, the pedagogical design of the course and the learning aims built upon adapting the 21st century skills framework by Binkley et al. (2012; see Tables 1 and 2). The framework includes ten key skills categorized under four topics: (1) ways of thinking, (2) ways of working, (3) tools for working, and (4) living in the world. Table 1 presents the four categories of the framework, skills included in the categories and their general definitions regarded focal in this study. The pedagogical design based on this framework is presented later in this article.

Table 1: The 21st century skills framework (Binkley et al., 2012)

Category	Skills	Definition of skills
Ways of thinking	Creativity and innovation	Being able to create, elaborate and evaluate ideas, communicate them, others and develop them into applicable forms.
	Critical thinking, problem-solving, decision-making	Being able to reason, examine, interpret and synthesize ideas and information; evaluate and explain.
	Learning to learn, metacognition	Being able to dedicate time to learning, having discipline and perseverance, and being able to adjust own means of communication to foster the process.
Ways of working	Communication	Being able to communicate orally and in writing, to listen, read and understand.
	Collaboration and teamwork	Being able to conduct oneself professionally, leverage differences within a team to create new ideas, plan and manage work, guide and inspire.
Tools for working	Information literacy	Being able to search, access and evaluate information from various sources, to distinguish relevant information, to produce information in multiple forms and to use information systematically.
	ICT literacy	Being able to use digital technologies meaningfully for the task at hand.
	Citizenship	Being able to help to solve problems affecting communities on different levels.
	Life and career	Being able to use feedback to advance own work, negotiate diverse views to reach a solution, to manage time and workload, work effectively independently and in teams, set and meet goals, guide and lead.
	Personal and social responsibility	Being able to communicate and express frustration constructively, create confidence and to negotiate.

The framework is extensive and each of the ten skills included in it can be perceived as own detailed research areas with specific definitions and methodologies. The aim here, however, was not to study deeply each individual skill and produce measurable knowledge of learning outcomes related to them, but instead to use the definitions provided in the framework, adapt the framework in an inter-university course in higher education context, operationalize it into assignments, in the completion of which students potentially should use the skills (Binkley et al., 2012) and most importantly, see how students experienced this learning process and how the skills were manifested in it. Students' experiences provide information for further development of the course.

As Mishra and Kereluik (2011) point out, not all skills included in 21st century skills frameworks are unique to this period. For example, the ability to solve problems, communication and collaboration have been critical skills for centuries. However, megatrends, such as digitalization and globalization, and the resulting changes in how people act and communicate in contemporary society require rethinking of these skills, their meaning and how learning could be promoted by redesigning learning environments and pedagogies (Dede, 2010; Kivunja, 2014; Mishra & Mehta, 2017; Rosefsky Saavedra & Opfer, 2012). The magnitude of global challenges and problems require multidisciplinary collaboration as well as the ability to create novel applications of information and technologies. This must be taken into consideration within the field of education and by those responsible for designing and developing learning environments and pedagogies (Tassone, O'Mahony, McKenna, Eppink, & Wals, 2018).

While higher education institutions have recognized the importance of multidisciplinary collaboration, relatively little research has discussed approaches to help students participate in and learn from cross-boundary teamwork that extends the boundaries of higher education institutions. To date, research in this area has primarily focused on long-term efforts for developing shared epistemic objects and practices, often within a specific socio-cultural community (e.g. Bereiter, 2002; Hakkarainen, Paavola, Kangas, & Seitamaa-Hakkarainen, 2013; Chan, 2013; Damsa, 2014; Stahl & Hakkarainen, 2019). As such, educational researchers are concerned that there is an increasing gap between knowledge work and narrow problem-solving capabilities that are promoted in higher education practices (e.g. Bereiter, 2002; Muukkonen, Lakkala, Kaistinen, & Nyman, 2010; Scardamalia et al., 2011).

Pedagogical starting points for cross-boundary teaming

In their recent article, Edmondson and Harvey (2018) argue that cross-boundary teaming has become an increasingly prevalent and important strategy to achieve the skills needed in the 21st century working life. It involves collaboration between individuals with different backgrounds and expertise, who temporarily join together to complete an unfamiliar project. Cross-boundary teaming thus contrasts with teams that are well-bounded, reasonably stable, and functionally homogeneous (Edmondson & Harvey, 2018).

Previous studies have identified some pedagogical aspects that should be considered when promoting collaborative knowledge creation in educational settings. First, in cross-boundary teaming, a group of people needs to negotiate a shared object of activity (Hakkarainen, 2010). Prior findings have suggested that collaborative learning and knowledge creation can be successful when students solve ill-defined and complex problems arising from real-world phenomena (Hakkarainen, 2010; Krajcik & Blumenfeld, 2006; Vartiainen, 2014; Damsa, 2014). Such problems are characterized by emergent goals that are formed and modified by students themselves during the course of pursuing them (Scardamalia et al., 2011) and they intentionally bring into play multiple perspectives, multiple ways of working, and different habits of mind (Hennessy & Murphy, 1999; Hakkarainen et al., 2013; Lombardi, 2007).

According to Cress, Rosé, Law and Ludvigsen (2019), the mutual refinement of ideas through interaction constitutes the core process of collaborative knowledge creation. Problems and solutions being refined in the joint processes can be understood as epistemic objects that crystallize and promote evolving understanding or provide stepping stones for directing and advancing collective inquiry efforts (Stahl & Hakkarainen, 2019). In this process, the students need to share their expertise as well to search, evaluate and use information sources originating from outside the community (van Heijst, de Jong, van Aalst, de Hoog, & Kirschner, 2019). Constructive uses of authoritative sources underscore the improvement of ideas by using and applying, for example, academic resources, empirical evidence and experiments in the context of problem-solving process at hand (Chan, 2013; van Heijst et al., 2019). From this perspective, knowledge emerges as an interactional accomplishment based on a joint construction process, encapsulated into external artefacts, such as written notes, visual representations, digital or material artefacts (Damsa, 2014; Stahl & Hakkarainen, 2019).

However, collaborative knowledge creation does not necessarily come without challenges and conflicts (Näykki, Järvelä, Kirschner, & Järvenoja, 2014). Previous research has shown that the success of teamwork relies on co-regulating and coordinating collaborative actions towards shared goals (Damsa, 2014). Construction and pursuit of shared object also requires creation of team-level mental models about the task requirements, procedures, roles and responsibilities (Edmondson & Harvey, 2018) as well as good practices for distributed teamwork enabled by technological tools (Hämäläinen et al., 2017; Kivunja, 2014; Muukkonen et al., 2010).

According to Muukkonen et al. (2010), distributed teams can work purely virtually or be blended teams, which interact both face-to-face and virtually. In either case, technology enables various types of mediation for collaboration and learning, including epistemic mediation related to creating and working with knowledge artefacts; pragmatic mediation related to planning, organizing and coordinating work processes; social mediation for building and fostering social networks and relations; and reflective mediation to support making visible,

reflecting on and transforming joint practices (Kivunja, 2014; Muukkonen-van der Meer, 2011; Paavola, Engeström, & Hakkarainen, 2012).

Existing body of research literature acknowledges benefits in both blended and online learning as instructional designs. Blended learning is defined here as a course-level pedagogical design that combines phases of face-to-face and online activities (Boelens, De Wever, & Voet, 2017; Graham, 2006). Previously it has been reported that blended learning can promote interactivity, authenticity and flexibility of the learning process, improve learning outcomes, reduce the number of drop-outs (Poon, 2013), and enhance meaningful learning in higher education (Zurita, Hasbun, Baloian, & Jerez, 2014). Online learning is based on using digital tools and environments to mediate communication and collaboration without face-to-face interaction (Harasim, 2017). The advantages of online learning include for example flexibility of times and places when and where to study and having possibilities to combine information from different resources and contexts (Broadbent & Poon, 2015).

Despite the course option, a teacher's role is that of a facilitator and designer (Scheer, Noweski, & Meinel, 2012) during collaborative knowledge building. He or she must make it possible for students to transform information into knowledge to serve as the basis for creative, collaborative, critical and communicative problem-solving. It is also critical to enable explicit transdisciplinary real-world connections. Mishra and Mehta (2017) call for pedagogical sensitivity to context and the dynamics in student groups; to enable guidance and instruction in blended and online learning environments, such learning environments and pedagogical practices must be designed to bring students' learning processes visible to teachers.

In summary, knowledge creation is a principle-based approach, which defines core pedagogical values and principles rather than pre-defined and highly scripted activities (Zhang, Hong, Scardamalia, Teo, & Morley, 2011; Chan, 2013). Given the epistemic focus, these principles, rather than predictable and pre-established procedures, are needed to allow emergent and evolving process of knowledge creation (Chan, 2013). In such settings, students learn by co-designing and creating an epistemic environment that affords their boundary-crossing activities (Markauskaite & Goodyear, 2016). To promote 21st century learning, these pedagogical principles and starting points propose a clear transformation from a lecture-oriented and predetermined learning environment towards dynamic, evolving, cross-boundary networks (Vartiainen, 2014).

Research design

The DBR approach serves as a methodological framework for this study (Design-Based Research Collective, 2003; Mingfong, Yam Sam, & Ek Ming, 2010; Wang & Hannafin, 2005) and this paper reports results from the first DBR cycle. According to the iterative nature of a DBR process, the first cycle consisted of three phases: (1) designing the content and pedagogy for blended and online course versions of the new inter-university course, (2) implementing the pilot

version of the course in higher education settings, and (3) collecting and analyzing data. The following sections present these phases in detail.

Course design and implementation

The course was designed by a multidisciplinary team of eight persons, i.e. teachers, researchers and experts from the fields of education, forestry and bioeconomics during eight months period in August 2018–March 2019. As the new course was open to students from both universities and universities of applied sciences (UAS) regardless of their discipline, also the team members came from both university and UAS education. Team's diversity facilitated considering the course design from multiple aspects and assessing it also critically. The first and third authors of this paper were involved only in the design and research of the course, the second author was involved in teaching as well.

The new course, Collaborative Problem Solving in Multidisciplinary Networks (five ECTS credits), was designed with the aim of fostering higher education students' 21st century skills through collaborative problem-solving in cross-boundary teams in the context of forest bioeconomics. The course was run from April to June 2019. Originally, 41 students signed up for the course. Of these, 32 started the course assignments, and 24 completed the course. Of the group of students who completed the course, 18 (11 females and 7 males) participated also in this study. They came from two Finnish universities and three UASs.

Two course formats were available: a blended learning version—TeamCamp—that included a three-day intensive period after the preparatory phase of the course (see Table 2) and an online version—DigiCamp—that involved no face-to-face contact. Students were free to choose between blended and online course options. The pedagogical design was informed and guided by the constructs of online and blended learning (Boelens et al., 2017; Graham, 2006; Harasim, 2017), cross-boundary teaming (Edmondson & Harvey, 2018; Hennessy & Murphy, 1999, Lombardi, 2007), the principles of collaborative knowledge creation and problem-solving (Damsa, 2014, Hakkarainen, 2010; Hakkarainen et al., 2013; Krajcik & Blumenfeld, 2006; Scardamalia et al., 2011), as well as the framework of 21st century skills (Binkley et al., 2012). This interwoven nature of theory and practice is a key characteristic of DBR (Mingfong et al., 2010; Wang & Hannafin, 2005). In other words, theoretical aspects create the basis for collaboration between researchers and practitioners. Practical implementations carried out during the iterative stages aim to create knowledge that has a developmental impact at both the practical and theoretical levels. During the 11-week course, students completed eight assignments. Each assignment had to be completed successfully before students could move on to the next one. Table 2 presents the overall design and organization of the course and the assignments.

Table 2: The course design

Description of assignments and activities students engaged in	**Learning objectives** 21st century skills proposed by Binkley et al. (2012) are bolded	**Interaction with teachers**
Preparatory assignments (1–4) 1. Provide introductions through FlipGrid videos.	To develop oral **communication** skills via video introductions.	Feedback if needed.
2A. Determine perceptions of the skills and knowledge needed in the field of forest bioeconomics. 2B. Present students' learning objectives.	To develop **metacognition** by setting goals (**life and career**) and completing a self-evaluation at the end of the course.	Teacher accepts or rejects the submission. Feedback if needed.
3A. Familiarize students with the field of forest bioeconomics through the provided materials. 3B. Formulate five questions about the forest bioeconomy.	To develop **multiliteracy** by managing information from various sources and engage in **critical thinking** and **problem-solving** by asking personally meaningful questions.	May follow students' activity during step A via DigiCampus. Teacher accepts or rejects submission.
4. Interview a forest bioeconomics professional about the company's operations related to a forest bioeconomy and the key knowledge and skills needed in the field.	To develop the ability to interact with professionals in the forest bioeconomics field (**life and career**).	Teacher accepts the subject of the interview. Assignments submitted to a discussion forum. Possibility for interaction and feedback.
Development challenge (5–6) 5A. Negotiate the rules of collaboration for your team. 5B. Choose the ten most interesting questions from the pool of questions created for assignment 3. 5C. Categorize the chosen questions with one's team to find a common theme of interest. 5D. Formulate a development challenge for the team. 5E. Take advantage of scientific research and expert knowledge to develop an executable solution for the challenge.	To develop the ability to **collaborate**; **communicate**; and use technologies and social networks to search, organize, evaluate, create and communicate information (**multiliteracy**). To become willing to leverage others' strengths to accomplish a common goal, understand strategies for tackling ill-defined problems and base decisions on evidence (**critical thinking, problem-solving and decision-making**).	TeamCamp: Interaction with teachers possible during the whole process of teaming and formulation of the development challenge. DigiCamp: Interaction with teachers possible during the process of teaming through the team's discussion forum and email. Teacher provides feedback on submitted report through the team's discussion forum.

6. Prepare a short pitch about the team's solution using FlipGrid.	To develop **communication** skills by presenting results in the form of a video.	Feedback if needed.
Assessment (7–8) 7. Perform peer assessments based on other teams' pitches created using FlipGrid.	To develop **personal and social responsibility** by learning to provide constructive feedback in a professional manner.	Feedback if needed.
8. Perform self-assessment and reflect on the learning objectives and process of working in a team.	To develop **metacognition** and the **ability to learn** by reflecting on the objectives of learning.	Feedback if needed.

The first four assignments were *preparatory assignments* that students completed individually. They were intended to introduce students to one another and present an overview of the field and the basic concepts of bioeconomics. To support work on the preparatory assignments, students were provided with various materials through the DigiCampus virtual learning environment (VLE), including instructions for the assignments and an introduction to the field of forest bioeconomics and its basic concepts. The materials took the form of video lectures by teachers, introductory videos by experts of different sectors of bioeconomics, articles, and a list of references. Teachers introduced themselves in videos via the FlipGrid application.

During the preparatory assignments, teachers were tasked with monitoring students' efforts, accepting or rejecting students' submissions and giving feedback on assignments when needed. Teachers were able to follow students' progress in the DigiCampus VLE. In preparatory assignment 4 (interview a forest bioeconomics professional), teachers accepted or rejected the interview subject, and in cases of rejection, guided students towards a more suitable subject.

Assignments 5 and 6 served as the core of the course, providing a *development challenge* to be completed by cross-boundary teams (Edmondson & Harvey, 2018). The formation of the teams was mainly based on the students' primary disciplines, but their former studies and work history were also considered (Table 3).

Table 3: Formulation of cross-boundary teams

Team	Students (n = 18)	Team members' main disciplines (U = university, UAS = university of applied sciences)
TeamCamp 1	3	Bioeconomy and Circular Economy (UAS), Forest Engineering (UAS), Forest Science (U)
TeamCamp 2	3	Bioproduct Engineering (UAS), Geography (teacher, U), Forest Engineering/Natural Resources Economics (UAS)
DigiCamp 1	3	Educational Sciences (primary school teacher, U), Biotechnology/Forest Science (U), Forest Engineering (UAS)
DigiCamp 2	3	Educational Sciences (primary school teacher, U), Environmental Politics (U), Educational Sciences (home economics, U)
DigiCamp 3	3	Educational Sciences (primary school teacher, U), Forest Engineering/Bioeconomy and Circular Economy (UAS), Forest Engineering/Bioeconomy (UAS)
DigiCamp 4	3	Educational Sciences (primary school teacher, U), Forest Engineering (UAS), Forest Engineering (UAS)

The teams were provided with their own discussion forums in the DigiCampus VLE for asynchronous communication and a chat for synchronous communication, but they were encouraged to use any suitable applications to make teamwork as easy as possible. The teams were also encouraged to actively interact with the teachers or other experts they believed could help them complete their development challenge. They had access to the materials provided for the preparatory assignments, but they had to search for and choose any additional materials. When starting to work on the development challenge assignments, the teams were required to agree on the rules for their work (assignment 5A) and post them on the discussion forum in the DigiCampus VLE to ensure that strategies were in place to deal with possible conflicts or disagreements (Edmondson & Harvey, 2018; Muukkonen et al., 2010).

For assignment 5B, each student chose ten interesting questions about forest bioeconomics from the pool of questions to which all participating students contributed during preparatory assignment 4. Next, the chosen questions were categorized and analyzed by each team to formulate a common development challenge (i.e. an ill-defined question). Teams were tasked with developing solutions to these challenges that could be operationalized, required research-based knowledge and utilized modern technology. The teams had to prepare a written report as well as a five-minute video pitch for their solution using FlipGrid. Examples of teams' development challenges include a mobile game application to enhance national health, a project funding application to promote

forest owners' engagement in forestry and a concept for using virtual reality to create a virtual park in a sheltered home.

Following the 21st century skills framework (Binkley et al., 2012) and the pedagogical starting points presented above, the idea of the development challenge assignments (5 and 6) were to engage students in a co-creative process that entails (1) communicating and collaborating in cross-boundary teams with people of different backgrounds, (2) using digital technologies and social networks to promote teamwork (3) developing multiliteracy and critical thinking skills by making students search for, organize and evaluate information; (4) basing decisions on evidence; (5) make their process visible through communicating information within their teams and to teachers and other students (6) being flexible and willing to consider others' ideas and ways of working; and (7) identifying and leveraging others' strengths to accomplish a common goal.

During the development challenge phase, teachers created the cross-boundary teams and re-assigned students in case of dropouts, which happened only in the DigiCamp course. Teachers were also involved in helping teams formulate their development challenges, and they had to accept the topic of each challenge before the teams could move on. For teams within the TeamCamp course, this interaction, that made students' and teams' process visible to teachers (Mishra & Mehta, 2017) took place face-to-face. For teams within the DigiCamp course, interaction took place in discussion forums within the DigiCampus VLE or via email. If DigiCamp teams needed help, teachers clarified the instructions. At the end of the development challenge phase, teachers gave feedback to the teams about their pitches and reports. The TeamCamp teams participated in a feedback session via Skype for Business, and the DigiCamp teams received feedback through their discussion forums in the DigiCampus VLE.

The last two assignments of the course concerned *assessment*. Each student assessed and wrote a one-page analytic summary of the other teams' pitches. To assess their own performance and learning within the course, students reflected on the learning objectives they set at the beginning of the course and how they worked in their teams. The objective of this phase was to develop students' personal and social responsibility by teaching them to provide constructive feedback in a professional manner and to help them develop metacognition and the ability to learn by reflecting on learning objectives. In addition, it taught students how to reflect on the process of working in cross-boundary teams, analyze changes in their thinking and consider how these changes may affect their working processes in the future. Teachers accepted or rejected these submissions and gave feedback when needed.

Research questions and the data collection and analysis procedures

The second phase of the first DBR cycle was to collect data and analyze it. This study aims to gain empirical knowledge of higher education students' experiences from a blended or online course that was designed to promote their 21st century skills through cross-boundary collaboration and problem-solving in the context of forest bioeconomics. The research questions were formulated as

follows: (1) How are the 21st century skills manifested in students' experiences of cross-boundary collaboration and problem-solving? (2) Are there differences in the experiences of students from online and blended course options?

To collect data, in-depth group interviews were performed after the course. The interview data is described in Table 4. Throughout this article, students' names are anonymized to protect their identities.

Table 4: Summary of data

Teams	Length of interview	Transcription (words)	Length of WhatsApp discussion (words)
TeamCamp 1 Hugo Elsa Nick	1:01:44	7170	
TeamCamp 2 Audrey Vince Eddie	0:53:57	5276	3001
DigiCamp 1 Mona Edith Jake	0:45:20	5028	8561
DigiCamp 2 Susie Mary	0:56:52	7140	
DigiCamp 3 Maggie Steve John	0:31:36	3800	
DigiCamp 4 Vera Tracy Ann	0:39:28	4083	

Altogether, six in-depth group interviews were carried out in August 2019 with two teams from TeamCamp and four teams from DigiCamp. The interviews were conducted using Skype for Business and they were recorded. Students were asked for a permission for the recording (Sieber, 1992). The interview questions were designed through collaboration between the authors of this article. The students were first asked about their background and motivations for enrolling in the course. After that, the interviews' structure was organized to focus on students' experiences from the three phases of the course (preparatory phase, development challenge and assessment). As the aim of this study is to see how the 21st century skills were manifested in students' experiences of

collaboration and problem-solving in cross-boundary teams in the two course options, a particular focus of the interviews was on the development challenge phase and most of the questions focused on that (Gray, 2014). Students were asked to reflect on their thoughts and experiences regarding the individual assignments, the collaboration and communication in their cross-boundary team, the tools and resources that were used and the meaning they gleaned from the course activities. Students were prompted to illustrate and expand their responses to increase the validity of data. To strengthen the reliability of the data, the first author was responsible for carrying out the interviews, and the other two authors listened, followed the interview to assure that the questions were presented in a same way during each interview. The other two authors presented additional questions at the end, when needed (Gray, 2014). The interviews were transcribed verbatim. In total, the transcribed interview data include 32497 words. Additionally, as the teams reported that they used WhatsApp (WA) as a tool for interaction, they were asked for their permission to include WA conversation threads as supplementary research data. Two teams gave permission. These textual conversation data include 11562 words.

Deductive content analysis was performed for both the interview and WA data. NVivo qualitative data analysis software was used to assist the analysis. The 21st century skills framework and the definitions of individual skills in it (Binkley et al., 2012; Table 1) were used as the analytical framework. To consider how the 21st century skills were manifested in students' experiences, their descriptions related to the ten individual skills in the framework were interpreted from data and coded into categories according to the framework. The second research question focused on finding out the differences between blended and online course versions. As the study was conducted during the pilot course implementation, the interpretation of these differences at this point is based only on qualitative data and analysis, not on quantitative or quantified data. Therefore, the results are to be considered preliminary and providing general level information, and as such, serving as a basis for re-designing the course and the blended and online course options. The first author conducted the initial analysis, which was validated through discussing them within the team of three authors. The results are presented in the following section.

Results

The following sections present the results to the two research questions.

The manifestation of 21st century skills in students' experiences

The first research question concerned, how the 21st century skills were manifested in higher education students' experiences of cross-boundary collaboration and problem-solving in the context of forest bioeconomy. It should be noted that although the framework (Binkley et al., 2012) defines the ten 21st century skills individually within four categories, in students' descriptions of their experiences these were often manifested as intertwined. The results are presented in Table 5.

Table 5: The manifestation of 21st century skills in students' experiences

Category	Skills	Activities (n=references in data)
Ways of thinking	Creativity and innovation	Creating new ideas (29), Developing ideas into applicable forms (7), Applying creative ways of working (2)
	Critical thinking, problem-solving, decision-making	Evaluating and synthesizing (27)
	Learning to learn, metacognition	Dedicating time for learning (6)
Ways of working	Collaboration	Leveraging differences within a team (18), Planning and managing work (15), Inspiring and helping others (2), conducting professionally (1)
	Communication	Advancing teamwork through communication (5)
Tools for working	Information literacy	Searching information (13), Evaluating information (12)
	ICT literacy	Learning new technologies (11), Technologies used: WhatsApp (12), Online word processor (7), DigiCampus (4), Flinga (2), PowerPoint (2), FlipGrid (2), Email (2), Conference calls (2), Phone calls (2), Laptop video camera (1)
Living in the world	Citizenship	Addressing a global challenge (5), Addressing a national challenge (3)
	Life and career	Managing time (13), Using feedback to advance work (15), Managing workload (5), Negotiating diverse views (2)
	Personal and social responsibility	Creating confidence (12), Expressing frustration constructively (1)

Ways of thinking

Creativity and innovation skills came about in students' descriptions of creating new ideas during formulating a development challenge on the basis of the questions created during preparatory assignment 3 (see Table 2). They had to develop ideas into applicable forms, be precise in defining their development challenge, keeping it reasonable and not too broad.

> Hugo: "Originally that question was so wide, I didn't really know which way to proceed. We had those initial goals but didn't really know how it would turn out to be in the end. But it developed while we worked on it. It was new to me—I mean when the question is such a raw one—how you elaborate it, revise and rewrite it. It was totally new to me."
> Elsa: "Yeah, they said I had a creative way of working."
> Hugo: "There was creativity for sure. With my engineering background, it would have been quite... [laughing] I did not know of such working methods." (TeamCamp, team 1)

The WhatsApp discussion threads used as supplementary data reveal the brainstorming and idea-testing processes that took place while teams worked on the assignment. The students actively exchanged ideas, such as how their solutions could be used in real-life contexts or commercialized.

> Jake: "We have to widen this idea also for the elderly and the young. [...] What if we had them [virtual reality glasses] in workplaces?"
> Mona: "And one could borrow them during breaks. And go trekking for 15 minutes. [...] Should we market so that companies would invest in them?"
> Jake: "Yes. Companies could use them for employees' micro-breaks. Social and health care could use them in elderly care. [...] Is there an NGO that does volunteer work with the elderly? [...] They could get some funding for purchasing them, too." (WA, DigiCamp, team 1)

Skills related to critical thinking, problem-solving and decision-making were manifested in students' descriptions as a process of evaluating own and team's work and synthesizing it, and deciding how to delineate their challenge with regards to the assignment. Through this process teams advanced the creation of the solution to their development challenge.

> Mona: "Those elements of forest are interesting, but not necessarily relevant here. I used red color to tag things that I think could be taken off."
> Jake: "Ok. I thought they would specify the arguments, but if they seem irrelevant, we'll take them off."
> Mona: "This would be good text if our report should be 10 pages long. What about those references? Should we use just a link or write them scientifically. Now there are both ways used. And I would remove all Wikipedias." (WA, DigiCamp, team1)

Manifestations of learning to learn and metacognitive skills in students' descriptions of their experiences were related to students' experiences of having to dedicate time to learn something new. In general, the idea of developing a

challenge and creating a solution to it was a new method of working for some students. Students who did not have prior knowledge of forest bioeconomics brought about in their experiences how they got to know contextual knowledge and understandings and how they perceived integrating these themes into their own disciplines and personal lives. Students with related backgrounds (e.g. forestry) described that their existing knowledge was deepened and broadened.

> Vince: "Yeah, the concept of a development challenge was a strange one, but soon I realized that we were supposed to identify a disadvantage and offer a solution or measures to solve it, so it became concrete quite soon and we all were able to use our know-how. [...] And the accumulation of information that happened, and communication with others...it was easy to work together when we had a lot of different thoughts and ideas." (TeamCamp, team 2)

> Jake: "I had some existing knowledge, but now I looked into this [forest bioeconomics] more deeply. [...] the video recording was quite exciting for me. Edith had written the text, and I would have told things a bit differently, but I did not have enough resources to correct it. I trusted Edith's text in the end, but I had to learn. But even though it was difficult, I do not perceive it negative, but fun [...] it's just so that you need to get out of your comfort zone to learn. [...] I also had to learn video editing for this." (DigiCamp, team 1)

> Hugo: "My experience of forest bioeconomics is that it is focused on such a narrow area although it has a huge potential… This course truly helped to open my eyes to see how broad industry this [forest bioeconomics] is."
> Elsa: "[...] Together, we look how far we have gone, and that is enough; we do not have to reach for the stars, but to keep it fair and human. Being able to learn is the goal." (TeamCamp, team 1)

Ways of working

Collaboration and teamwork skills were most often manifested in students' experiences through descriptions of leveraging both knowledge and skills-related differences within a team. Teams reported that they did not assign particular roles in their teams, but acknowledged during interviews how they divided the workload and how team members had contributed to joint effort. Differences in team members' level of knowledge about bioeconomics enabled some students to practice, for example, serving as an expert within a team including also non-experts.

> Jake: "I think that I knew something about the elderly care and Mona was familiar with the youth."
> Mona: "Yes.

> Jake: "I think that at some point I was walking on thin ice with the whole thing, but I guess that was the point here—to look at things from a totally different point of view. [...] We had different kinds of expertise in our team. Some were more skilled in word processing and the work was divided accordingly. I think that using your own strengths in the process makes it meaningful." (DigiCamp, team 1)

> Mary: "I think it was wonderful to show my proficiency [laughing]. It really was. I think you had excellent questions." (DigiCamp, team 2)

Planning and managing work seemed to be a constant process from the beginning of the development challenge phase to the end. Both the interview data and the WhatsApp threads show that negotiating timetables and how to proceed with the challenge were central here. In general, students seemed to perceive collaboration and teamwork as meaningful aspects of the course.

> Eddie: "Audrey, are you going to do something today? We can call if you feel like exchanging ideas. They might become clearer that way. There are quite many repetitive points in our funding application."
> Audrey: "I'll try to do this now as the men are outside and perhaps also in the evening after sauna."
> Eddie: "So we'll call in a moment? 15 minutes and I'm on my laptop."
> Audrey: "OK by me." (TeamCamp, team 2)

The whole completion of the development challenge was based on students' communication within the team and carrying out a collaborative writing process. As the challenge was quite ill-defined and students had to formulate their precise development challenge assignment as a team, it was not possible to complete the course without communication within the team. Students did not share experiences of having difficulties related to communication, but mentioned the meaning of communication for the team's process for example from teamwork and team dynamics points of view. As the list of tools used during the process shows, students used various kinds of media in their communication.

> Susie: "Interaction skills, for sure and group work... [skills], you know. As we did not see each other, we had to find ways to explore, how to be in this team, what kind of style suits us, how do we work, when do we work and when not. All this, you had to explore." (DigiCamp, team 2)

Tools for working

Information literacy skills were manifested in students' experiences through activities of searching and evaluating information. In this course, students had

access to a collection of materials on forest bioeconomics in the DigiCampus VLE, including video lectures, articles and links to online resources that introduced students to the basic concepts and topical themes within the field. To complete the development challenge, students had to search for various kinds of additional material, get acquainted with the information and think about how it could be applied to solve the challenge.

> Steve: "I used Statistics Finland to calculate the percentages." (DigiCamp, team 3)

> Vera: "I looked at the materials at DigiCampus first, what kinds of topics are covered there and then started to think, what would be sensible keywords to use when searching for relevant information."
> Ann: "I just surfed all around the Internet, one keyword took me to point A, that led to point B and then I was already in C and D, so it kind of sprawled, but I found all kinds of interesting research data and all." (DigiCamp, team 4)

As the information flow was broad and a variety of sources were used, students described they had to evaluate it to identify usable, reliable and valid information for their purposes, which was perceived difficult at times.

> Vera: "Well, for me, as I was looking for information about the health benefits, there were plenty of these health sites and it was really difficult to figure out where their information was from. I had to leave out lots of interesting information because I did not accept it as a source. I would have wanted to find more research information." (DigiCamp, team 4)

> Elsa: "Of course it is good to evaluate, where the source is from; which research institutes, what kind of a study and what methods were used. Perhaps the nature of our task was more of a general one, so we looked at a variety of sources. It would have required more time and negotiating, if we would have wanted to take a certain direction with the use of references." (TeamCamp, team 1)

Students were encouraged to seek experts other than the teachers and interview them to gather information, but none of the teams reported that they sought help from such sources. Teachers' role as experts was critical at the beginning as well as that of experts presented through the materials in DigiCampus VLE, but during the teamwork phase, students did not report that they needed much guidance in respect of this.

> Elsa: "Before we started to work, we discussed with Erica and Helen about our themes; we had decided that our theme would be sustainable forestry, and we had many goals so we talked about them. Thus, there is this common thinking on the basics

> and we got some ideas from experts. Of course, the themes of the expert lectures on TeamCamp can be seen in our theme." (TeamCamp, group 1)

In terms of developing the course further and paying attention to teachers' roles, it is important to acknowledge that not all of the teachers' roles were clear during the course according to students, and their responsibilities regarding the course were not expressed to students clearly enough. However, in general students perceived it as positive that teachers had backgrounds in diverse disciplines. In addition, they reported that it was easy to get help when needed, as there were several teachers available.

> Eddie: "I was thinking more about what was each teacher's role; it wasn't quite clear all the time. Others were more active and others significantly more passive during the course. Of course, I do not know what each teacher had done before or after the course, or how the workload was divided, but it was not clear. On the other hand, it was good to have an opportunity to ask and get to know many teachers and hear multiple aspects and discussions." (TeamCamp, team 2)

Based on students' experiences, all teams used quite similar set of digital tools during the course. Through the DigiCampus VLE, students had access to course assignments and materials and the ability to form small teams. Flinga was used to present questions, and FlipGrid was used for introductions at the beginning of the course and for pitching solutions to the development challenges. Apart from these applications, which were part of the course assignments, students were free to choose which tools to use. All teams used digital tools with which at least some of the team members were already familiar (i.e. phone calls and WhatsApp for communicating, brainstorming and sharing materials and ideas). The teams also used an online word processor to write the report, which was a new tool and working method for some students.

All teams reported that they used WhatsApp to communicate and learn how to utilize each other's strengths to address the development challenges. DigiCamp teams also used WhatsApp when getting to know each other. Students reported that this application was selected because they saw it as a fast and flexible way to communicate and because it enabled multimodal communication, which some perceived as a strength. Feelings were conveyed through vivid use of emojis. The online word processor enabled students to monitor the team's progress, and seeing other team members working on a common assignment motivated students to contribute.

> Susie: "I think that I did send some voice messages to you, some morning lectures [laughing]; it felt easier not to write and to fiddle with texts and words, but to be able to record my own speech and sent it to gals and they can then listen to it...." (DigiCamp, team 2)

> Nick: "Our working process was quite interactive there in our online document."
> Hugo: "Yes, it was a really nice working method, to see all the time what others have already written. It also sort of challenges oneself. For example, for me, working on written assignments has been really difficult, and now seeing that others had already contributed forced me to produce material right from the start. To not to perform any worse than others." (TeamCamp, group 1)

Tool-wise, the most challenging and educational phase seemed to be the one in which students created a video pitch at the end of the course. This required students to consider not only technical aspects but also multiple aspects related to narrative. For example, teams discussed the script and location where the video should be shot.

> Jake: "What [do] you think about shooting the pitch in a forest?"
> Mona: "Yes, I think that would be nice."
> Mona: "That video could open up our topic more than the report."
> Jake: "I was thinking that if we are marketing our report it would be most successful in a forest environment. It would illustrate all the hummocks and cones."
> Mona: "A park-laboratory in a sheltered home, that's our idea." (WA, DigiCamp, team 1)

Living in the world

The manifestation of citizenship skills was not pronounced in data. In the interviews, students shared some thoughts, how topical issues had affected defining teams' development challenge, but they did not really speak out, how they perceive their solution would help to solve these issues, nor was it possible to interpret it from the data.

> Susie: "Well, climate change at least. That came to mind… that has been a topical issue in the area of logging, so it guided me and made me think." (DigiCamp, team 2)

In this course, life and career skills were manifested through experiences of managing teamwork goals and timelines, using teachers' feedback to advance team's work, managing workload and negotiating diverse views. Students reported having other commitments in addition to their studies, which affected how students organized and proceeded with their studies. This came about in the group interviews and WhatsApp discussion threads. Many of the students had families, and as the course was run during the summer, students who did not have a steady job were working part-time or full-time at a summer job. The course had fixed deadlines for returning assignments, but not for lectures, providing students the flexibility to organize the teamwork in a way that suited their life situations after negotiating the division of tasks.

> Tracy: "And even though we've had very different timetables... I told the other group members that I have done lots of evening shifts now at work and I've got out of work at 7:15 PM at earliest [...] so the timetables have been quite challenging and I haven't had regular working hours, it has been challenging to [perform] communication and planning. But we have managed to proceed with the task well, andI have been able to count on others to do their part as well." (DigiCamp, team 4)

> Mona: "Well, we [the team] did this quite independently. We got some comments when we returned this for the first time and used them to correct our work." (DigiCamp, team 1)

Personal and social responsibility skills were manifested in students' experiences through descriptions of how the team members created confidence within the team during their working process. Particularly, it was perceived important to be able to trust that others would contribute to the joint effort.

> Tracy: "Quite simply, our team was really nice. It was rewarding to work together [...] we all contributed."
> Ann: "Yes, we didn't have to think, whether or not we would finish [...] one was able to trust this group, that we got this." (DigiCamp, team 4)

In the TeamCamp version of the course, teachers were able to see this aspect from the teams' dynamics during the three-day intensive period at the beginning of the course, but in DigiCamp, teams' dynamics remained relatively invisible to the teachers and researchers. As the teams collaborated independently on online platforms of their choice, teachers were unable to see students' communication or identify potentially challenging communication situations. The WhatsApp discussion threads revealed how feelings of frustration were expressed and handled in the group.

> Audrey: "I feel a bit miserable right now. Yes, I asked for help with that one thing, but I meant like a sentence or two. As I now returned to writing this, half of my text was gone. Also, I meant to sort the references now, but they have been already sorted. I would really like to participate in this team work, but it is a bit difficult if everything is done for me."
> Eddie: "I'm sorry, I didn't mean to harm your feelings in any point. Perhaps I got a bit carried away with this. I'll settle down now."
> Audrey: "Another thing is that is this already too wide? [...] No, I mean that it is wonderful that you are excited! It would just be nice to do something myself."
> Eddie: "It is great that you brought this up, one doesn't always notice these things. Just take it and make it your own. It'll be good."

> Audrey: "Let's just go with this as the deadline is so close. Let's just fix the list of references." (WA, TeamCamp, team 2)

Differences in students' experiences

The second research question focused on finding out if there were differences in the experiences of students from blended and online course options (TeamCamp and DigiCamp, respectively). Regarding the pilot course implementation, these results are based on qualitative data and analysis and therefore they are to be considered preliminary.

The pedagogical design of the preparatory phase was similar to students in both course options. The development challenge phase, however, was organized differently. Students who participated in the TeamCamp had a three-day intensive period and met face-to-face at the beginning of the development challenge phase (see Table 2). The idea was to provide them with a possibility to get to know each other quite well right at the beginning of the development challenge phase and to start formulating their challenge face-to-face. The intensive period also provided an opportunity for teachers to help students defining the challenge in a more profound way. Students who participated in the DigiCamp version of the course relied only on mediated forms of communication throughout the process. The DigiCamp teams had to get in touch with teachers online, which might have diminished the role of teachers as resources for the DigiCamp teams. In terms of completing the development challenge, the DigiCamp teams were as successful as the TeamCamp teams, meaning that their development challenges were accepted to fulfill the requirements set to them and the members of the teams completed the course.

The most evident difference between the two course options is the dropout rate; no students dropped out of TeamCamp, but the dropout rate for DigiCamp was 42%. All drop-outs took place during the preparatory assignment phase or while teams were being created for the development challenge. For some teams the reassignment caused by the dropouts delayed the team-building and getting started with the development challenge. However, all the DigiCamp teams who started to work together completed the course. Although students' reasons for dropping out were not inquired, some dropouts indicated that their working hours during the summer just did not allow continuing with the course.

Concerning students' experiences during the development challenge phase, TeamCamp and DigiCamp participants' experiences seemed mostly similar. Based on the group interviews, however, it seems that the possibility to get to know one's teammates face-to-face during the TeamCamp intensive period promoted getting to know each other through real conversations. Although students reported experiencing the working methods in both DigiCamp and TeamCamp teams as interactive and aiming to reach a common goal, only the TeamCamp teams did mention actual conversations between members as a starting point for their development challenge. Students reported continuing using discussions as a method of working also during the writing phase of the report.

> Tracy: "And the nice thing about this was, that even though this was an online course, it was not just working alone, but there were also other people involved." (DigiCamp, team 4)

> Audrey: "Conversations. We discussed… our development challenge did not originate straight from any of those questions, that were already there, those one hundred and eighteen questions [...] based on those questions we just started to talk, we talked like a couple of hours, and based on that we came up with our topic [...] we had a kind of active attitude and just like you said earlier, conversational, so I think, that good skills of interaction were our team's strength at the end, that we were able to communicate and discuss about things."
> Vince: "Our working was a kind a conversational in the web document." (TeamCamp, team 2)

DigiCamp teams indicated that they did not actually divide roles or work tasks that precisely. It seemed that, even though they did not know each other that well, their working towards the common goal was still fluent. If someone articulated a special interest or expertise toward a certain task or theme than he or she was able to take that task, but otherwise the tasks were divided quite evenly—depending on, for example, each teammates' time schedules.

> Tracy: "In the end, we didn't think that much about who does and what, the pieces just clicked together, so it went really painlessly and we completed each other's thoughts of these parts." (DigiCamp, team 4)

> Edith: "Yeah, at first, we kind of divided the tasks, but then, which was a really nice thing, that as we were all really self-imposed, that the time schedules just didn't match that well, but then, if you were not working with the others at a certain point of time, then you did something else or offered to do something else and it went really quite well." (DigiCamp, team 1)

It seems that as the teammates in TeamCamp teams knew each other a bit better, also the tasks were divided a bit more on the basis of their expertise. The one who knew forestry or tourism better took also more responsibility of that part and if one was more talented in written communication then he or she took more responsibility of that part.

> Nick: "Earlier I have rubbed elbows a lot for example with the Finnish Forest Institute concerning tourism, and how would I say it, with forest owners and others, and I have always had to make things happen in practice and see how forest could be exploited in tourism so that all parties accept it without consequences." (TeamCamp, team 1)

> Audrey: "Eddie has the best skills in written communication... maybe Vince and I were more searching for information and Eddie combined it to a rational package. I don't necessarily have that much practical information of forests, so I searched for [information] from other sources have written and Vince was able to analyze it." (TeamCamp, team 2)

Conclusions

In keeping with the principles of DBR, the aims here were twofold. First, the study aimed to find out, how the 21st century skills were manifested in higher education students' experiences of cross-boundary collaboration and problem-solving in blended and online courses and to see, if there were differences in students' experiences from the two course options. The results are based on qualitative data and deductive analysis. Second, as the study was carried out as a part of the pilot implementation of the new course designed during the first DBR cycle, the aim is to use this information to develop the pedagogical design of the course.

Existing research literature has pointed out some critical aspects related to DBR (Anderson & Shattuck, 2010; McKenney & Reeves, 2013), which was used as the methodological approach in this study. The identified problems with DBR approach include for example possible researcher bias—which is related to qualitative studies in general, not just DBR— (Anderson & Shattuck, 2010; Barab & Squire, 2004) and the lack of practitioner input, which can result as researcher-led designs without contextual sensitivity (Leeman & Wardekker, 2011; Mingfong et al., 2010). In this study this critique was addressed through collaboration of teachers and researchers during design, implementation and analysis phases of the first DBR cycle. Through focusing on students' experiences from the course and finding out, how the 21st century skills were manifested in those experiences, it is aimed to strengthen the course design even further through enabling students to participate as co-designers. As students share their lived experiences from the course, they can be used to inform the pedagogical refinement of the course.

DBR entails a strive towards collecting data from multiple sources to gain versatile information. In this case, the main data was collected through in-depth group interviews and WhatsApp discussion threads were used as supplementary data. The interview data is limited in its power to reveal the original course of things—it is produced by students and interpreted by researchers. However, as this study aimed to gain *experiential* knowledge and strengthen students' voice in the design of the course, it was considered important to let students describe their experiences with their own words instead of using for example a questionnaire to produce statistical data. Group interviews fostered reflective approach to the topics covered in the interviews and the supplementary WhatsApp data confirmed the interpretations.

The framework of 21st century skills (Binkley et al., 2012) and the pedagogical premises of cross-boundary teaming (Edmondson & Harvey, 2018), collaborative and co-creative work on a meaningful and joint effort (Hakkarainen, 2010;

Hennessy & Murphy, 1999; Krajcik & Blumenfeld, 2006) consider students as active agents in the process and the pedagogical design followed these ideas. Teachers' role was to design and facilitate the course, guide students, provide and distribute materials and orchestrate implementation of the course from the beginning to the end (Scheer et al., 2012). Students were encouraged to contact experts other than the teachers and use them as resources to define and develop the development challenge and its solution. However, students did not take full advantage of this opportunity. This might have an effect on light manifestation of citizenship skills' perspectives in the data. When developing the course, experts' roles could be emphasized by, for example, asking bioeconomics companies, public administrators or non-governmental organizations to provide teams with real-life assignments to be solved. This would enhance the connection between the course and working life, but it could possibly risk students' role in knowledge-building and searching for information.

The participating students had diverse backgrounds in terms of their existing knowledge about bioeconomics and working methods. Some students had studied forestry or forest bioeconomics for several years, and for some, it was an entirely new area. In general, students perceived the diversity of cross-boundary teams as a strength. The process of defining a development challenge forced those who were already knowledgeable about the field to adopt new perspectives, and they had an opportunity to practice their role as an expert within a team. Additionally, students from universities and those from UASs seemed to have different habits of learning and working and they had to negotiate a common ground (Hennessy & Murphy, 1999; Hakkarainen et al., 2013; Lombardi, 2007). Students perceived this versatility as both challenging and beneficial.

In terms of digital tools, the cross-boundary teams relied on familiar tools for communication and teamwork. WhatsApp was efficient for managing teamwork, dividing tasks between team members, scheduling, monitoring teams' progress, sharing materials and encouraging others. In addition, it allowed students to convey emotions through the use of emojis and other forms of content than text. An online word processor enabled collaborative writing and monitoring of teams' progress. It seems that allowing students to use preferred tools in addition to those selected by teachers supported the overall completion of the course. From a technological perspective, this implementation of the course showed that organizing and orchestrating a blended or online course based upon cross-boundary teamwork and collaborative problem-solving does not require massive technological investments. Rather, it can be implemented by using digital tools that are freely available to everyone.

As both course options utilized various kinds of digital technologies, the students' free choice over these tools can also be perceived as limiting teachers' ability to monitor students' and teams' processes as suggested for example by Binkley et al., (2012). In this case the returning of individual assignments can be regarded as "touch points", which enabled following teams' working process and providing guiding and instruction. In blended course options, some of these

took place face-to-face and in online course option all of these were mediated by digital tools. From the perspective of pedagogical sensitivity (Mishra & Mehta, 2017), this is challenging as teachers cannot be proactive in their guidance or obtain detailed information about students' learning processes (Rasi & Vuojärvi, 2018).

The results provide several implications for course development. First, teachers' roles need to be clarified and explicitly communicated to the students. Second, to decrease the dropout rate, more effective facilitation practices are needed at the beginning of the course, particularly for students in DigiCamp course option. In addition, implementation of formative assessments in the middle of the course should be considered. Third, as both the DigiCamp and TeamCamp teams succeeded in their development challenge assignment, it is worth considering whether both course options are needed in the future. Developing one course option with a lecture-based introduction to the development challenge phase, either face-to-face or online, would allow more effort to be put towards facilitating students' work. This, however, would need to be carried out carefully as the drop-out rate in DigiCamp was high. Students who enrolled in TeamCamp were committed to participate in the face-to-face meeting and therefore might have had a clearer idea about the required time resources right at the beginning. Another aspect worth considering in terms of supporting team-building would be to assign the teams right at the beginning of the course. Fourth, the role of experts in the course needs further consideration. Expert participation could enhance authenticity and contextuality of the course, but their role as facilitators should be clear, providing also students with a possibility and a challenge of knowledge-building within the team. Finally, it is worth considering an international implementation of the course to enhance students' collaboration and problem-solving skills in multicultural cross-boundary teams.

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