Designing Connected Learning: Emerging learning systems in a craft teacher education course

Henrikka Vartiaien, University of Eastern Finland, Finland
Sinikka Pöllänen, University of Eastern Finland, Finland
Anu Liljeström, University of Eastern Finland, Finland
Petteri Vanninen, University of Eastern Finland, Finland
Jorma Enkenberg, University of Eastern Finland, Finland

Abstract
This socioculturally informed study aims to apply learning by collaborative designing (LCD) as an instructional model for the creation and studying of new kinds of connected learning systems in teacher education. A case study was organized at the University of Eastern Finland in the context of an information and communication technology (ICT) course aimed at craft student teachers' (N=13). A qualitative content analysis was used to describe the kind of learning systems that emerged when the students collaboratively designed an extended network of people, objects, and tools for their own learning and teaching. The results reveal that the student teams were active in designing and self-organising the learning environment in the pursuit of shared objects, and in using diverse tools and technologies for thinking and for collecting, organising and sharing information. Implications for designing connected learning and teaching across spaces and communities are also discussed.

Key words
connected learning, learning by collaborative designing, learning systems, teacher education

RESEARCH

Introduction

Collaborative design is a necessity when creating novel and effective solutions for the most interesting and important challenges in today's world (Fischer, 2014). The creation of new ideas, products, and models to tackle emergent and complex problems challenges people to cross boundaries of their existing communities and prevailing knowledge. Doing so entails creating novel and often far-reaching links to experts, communities, and information networks representing heterogeneous knowledge and competence (Lehtinen et al, 2014). This requires innovative recombination of multiple resources and tools (Francis, 2007), and the ability to make insightful and productive use of the collective resources in locally relevant ways (Mäkitalo et al, 2009).

If work and life in the twenty-first century are based on collaboration, creativity, problem solving, and being able to use technology to create new knowledge and expand human capacity and productivity (Binkley et al, 2011), education should promote such trans-disciplinary competencies and extend the boundaries of traditional learning environments. Yet even in the age of information and networking, most educational systems fail to promote the skills that students need for living and working in a knowledge-creating society (Thomas and Brown, 2011; Ito et al, 2013; Scardamalia, 2001; Scardamalia and Bereiter, 2006; Binkley et al, 2011; Valtonen et al, 2013). When reflecting on learning and teaching, there should be an increased emphasis on designing connected learning that knits together students' interests, academic life and diverse learning resources and networks (Ito et al, 2013). Consequently, the transformation efforts in education calls to develop organic, complex, and adaptive learning systems that evolve and connect students' learning ecologies with multiple contexts and communities, their social practices, and tools (Facer, 2011; Loi and Dillon, 2006; Kumpulainen et al, 2013; Lto et al, 2013). Thus, this study aims to apply learning by collaborative designing (LCD) as an enterprise for the creation and studying of new kinds of connected learning systems in teacher education.

Towards connected learning systems

According to Roth (2001), *design* is a heterogeneous process that connects, associates, and weaves together diverse tools, materials, artefacts, people, and agencies. *Learning by designing* can be seen as the process of arranging these elements to form novel systems, including the experimental construction of procedures, instruments, and material configurations (Roth, 2001). Empirical studies indicate that learning by designing can be applied in diverse educational contexts, including design and technology education (Kolodner et al, 2003; Roth, 1996; Lahti et al, 2004; Author, 2013) and science education (Roth, 1998; Author, 2013, 2014). These instructional approaches are largely based on design activities that emphasise collaboration, employ real-life contexts, and seek to develop open-ended learning tasks and projects that demand inquiry (Author, 2013).

Learning by collaborative designing (LCD) is a process that takes place in groups, communities, and networks, rather than by individuals (Seitamaa-Hakkarainen et al, 2010; Hakkarainen, 2010). According to Hennessy and Murphy (1999), LCD emphasises the creative process in which students actively communicate by sharing their ideas, thoughts, and skills; make joint decisions; and work

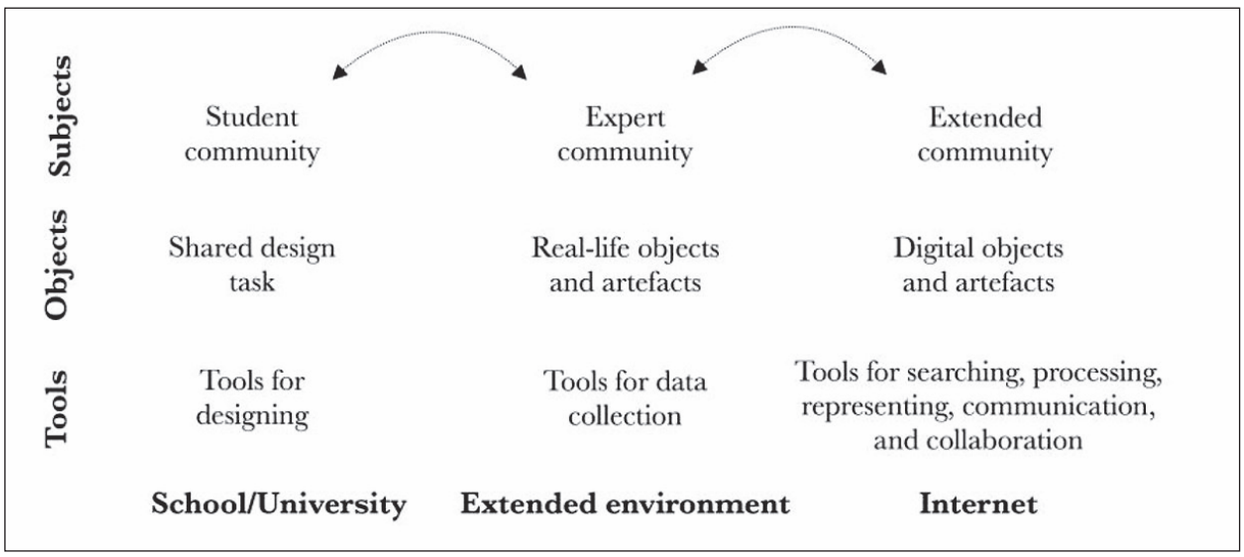

Figure 1. Design-oriented learning process described as a system (Author, 2014)

together to solve emerging problems. LCD also highlights the process of evaluating and modifying students' outcomes through dialogue and action. Seitamaa-Hakkarainen et al (2012) noted that students also need experience in working with expert communities, who can mediate their tacit knowledge, practices, and goals when solving problems, as well as mediate their values and identities.

Hakkarainen et al (2013) argued that in LCD, a group of students needs to have a shared object of activity that they develop collaboratively. These objects could be symbolic-material artefacts, such as questions and theories, or practices that often break the epistemic boundaries of school learning. Instead of traditional structured and context-separated tasks, the students solve ill-defined, complex, authentic, and challenging design tasks (Lahti et al, 2004; Author, 2013). Author (2013) argued that collaborative design projects also require sustained engagement in an iterative, i.e., spiral and cyclic, design process to develop, test, and apply new solutions involved in inquiry. Thus, design as a context for learning differs from the epistemological positions typically found in classrooms, because students have greater flexibility to negotiate their own goals and questions (Roth, 2001).

In design settings, students share a task around real artefacts, which have a central role in mediating the collaborative activities (Murphy and Hennessy, 2001). The shared learning task is communicated through externalisation (Seitamaa-Hakkarainen et al, 2012). Seitamaa-Hakkarainen et al (2010) noted that designing cannot be reduced to a mere play on ideas; to understand, share, and improve students' ideas, the ideas have to be given a material form. The students have to be both "minds on" (working with ideas, questions, and theories) and "hands on" (implementing or prototyping ideas by creating materially embodied artefacts). Through this externalization, the ideas and thoughts of the students become visible and improvable, enabling their collaborative advancement (Seitamaa-Hakkarainen et al, 2012). In this process, diverse tools and technologies may assist in externalising, recording, sharing, and organising all aspects and stages of the design process (Hakkarainen et al, 2013; Seitamaa-Hakkarainen et al, 2010).
According to Hmelo et al (2000), design activities can be a way to help students acquire a deeper and more systemic understanding of complex problems. In LCD, the learning is connected to real-life phenomena, which requires students to negotiate shared objects and related research questions, as well as to consider the artefacts and tools needed to enhance thoughts and actions for joint activities. Thus, when learning by collaborative designing, the people, objects, and resources are continuously interacting with each other, and in the process defining the emerging learning system as a whole (cf. Engeström, 1987). This emergent form of the system ultimately shifts the focus to the situated context formed by these elements. It proposes a clear transformation from a predetermined learning environment towards the creation of dynamic and extended learning networks for twenty-first century learning (Author, 2014). Figure 1 presents a design-oriented learning system of interconnected elements that derive their meaning in relation to each other (Author, 2014).

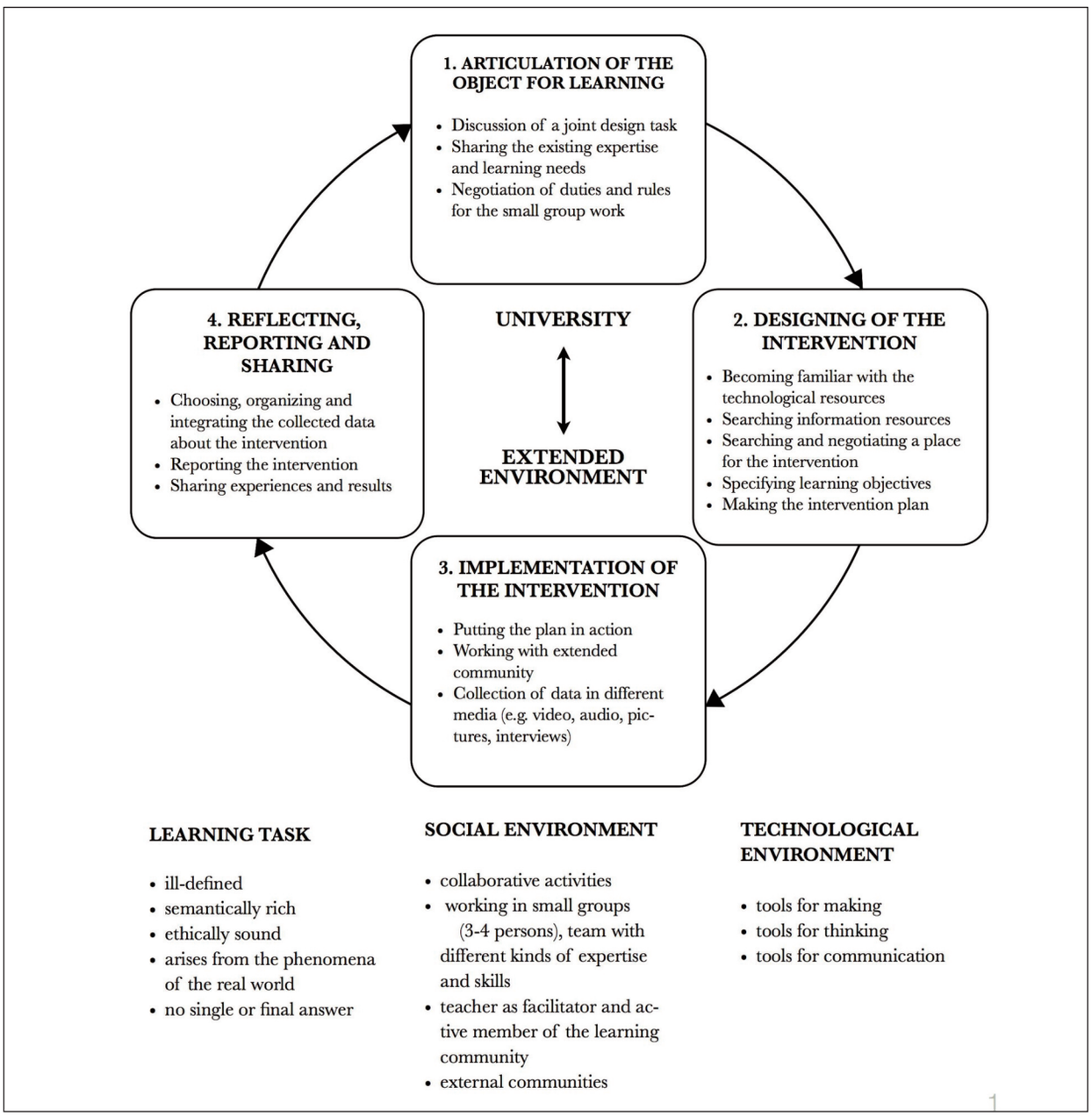

Figure 2. The applied instructional model of the study (Author et al., 2012)

Method

Aims and research questions

Promoting connected learning systems and the best pedagogical practices also creates a major challenge for teacher education in preparing students for their twenty-first century careers. To meet these challenges, this study aims to contribute to building a more coherent portrait of the nature of collaborative designing in connected learning environments, as well as its pedagogical applications in teacher education, by conducting a case study in the context of craft student teachers' (N=13) information and communication technology (ICT) course. As the study framework represents a systemic approach to learning, this study aims to examine the interrelationships among technologies, the communities around them and the learning activities that they support by addressing the following research question:

What kinds of learning systems will emerge when students collaboratively design a technology-mediated learning intervention for craft education?

Context and participants

The study took place in the context of craft teacher education in the University of Eastern Finland. In Finland, as is true for all teachers, craft teachers are required to have a master's degree to become a qualified teacher (5 years, 300 ECTs [a European grading scale]). The students will graduate as a master of education with a major subject in craft science and a minor subject in one self-chosen subject. All students in this programme complete courses about pedagogy and other education-related topics.

The case study was conducted as part of the students' pedagogical studies in the "Pedagogical Applications of Information and Communication Technology" course. The aim was to open the pedagogical opportunities of ICT to students. The course included eight contact lectures and 20 hours of small group exercises aiming to enhance students' practical skills in integrating ICT into teaching and learning. In total, 120 students participated in the course, but the present case study focuses on a target group of 13 second-year student teachers, whose major subject of study is craft science. At the time of the study, their teacher experience had been quite minimal so far.

The exercises began by creating a joint design task together with the student teachers. The students were given an open-ended learning task to design and implement a small intervention, where they had to integrate ICT into the learning processes with pupils. Because of the limited schedule of the university course, these interventions were expected to be carried out over two lessons. However, the teachers did not give specific target groups, guidelines, pre-determined aims or exact procedures for the intervention. Figure 2 describes the applied instructional model for connecting the elements of the learning system.

The intervention design sessions lasted 12 hours (six meetings), during which the students were asked to divide themselves into small groups. The teacher organised the learning environment by providing frameworks for students to ponder and share their existing expertise and learning needs, as well as to negotiate duties and rules for their small group work. In addition, various technologies, e.g., computers, smart boards, tablets, smart phones and hybrids, were offered. These were intended to give students a picture of the range of tools available to them and thus enhance their abilities to integrate them into their interventions. Although the students did not have experience in using technologies such as tablets or smart phones in their own teaching, the focus was not on teaching them the tools' technical properties but on encouraging them to examine these devices collaboratively and think of how they could be used at school. The students were also encouraged to use their own tools and technologies.

Data and analysis

To track down the emerging learning systems, upon completion of the small groups' work, the students were asked to write descriptions of their project activities and experiences based on formulas produced by the researchers. The documentation contained 1) descriptions of target pupils, 2) the theme of the intervention, 3) the learning task given to the students and their possible pupils' study questions related to it, 4) information resources used in designing and implementing the intervention, 5) communal resources used in designing and implementing the intervention, 6) the tools used in designing and implementing the intervention, 7) the students' description of the design and implementation procedure and 8) their thoughts on the intervention. These descriptions were the main research data in this study. The length of these descriptions varied from 7–11 A4 pages.

The same data collection instruments also worked simultaneously as a natural part of the students' process, with the aim of providing frameworks for the students to share their interventions among themselves and the wider community of students and university staff. In this study, the researcher closely participated in the activities of the learning community, serving as a university teacher-researcher in the design phase. The actual implementation was performed without the university staff.

To describe the emerging learning systems, a theory-dependent deductive research approach was applied to reveal the kinds of tools, people and objects for learning that were part of the students' learning projects (c.f. Figure 1). Although the school pupils and their teachers were part of the extended learning community, the main data of this study do not consist of the actions of the pupils.

Results

Table 1 summarises the described learning tasks, the learning community and the use of tools.

Emerging object of learning

When the students had the freedom to choose their target groups and topics for their intervention, all the groups decided to design and implement interventions related to their interests and future work in craft education. The way these students described the emergence of their intervention themes emphasised different design perspectives: using their existing experiences and networks, what the school teacher encouraged them to design, what they thought would be appropriate for their pupils and what the students themselves would want to learn. However, the task was also considered challenging, as the following examples from the reports show:

> In the beginning, the process was terrifying because it sounded really laborious and we were wondering when we would have time for the project…. We were quite negative towards it at first, but when we learned that we could go to the secondary school, we became

Small group	Emerging object of learning		Emerging learning community		Tools		
	Students' own design task	*Pupils' design task*	*University*	*Extended*	*For thinking*	*For making*	*For communication*
1 (N=3)	How tablets could be connected to creative activities	Design videos with the theme "self-expression" and make the props	• small group • peer students	Multicultural after-school club with • 13 pupils • responsible leader	• lectures • models of inquiry learning • tablets • Internet materials	• pen • paper • craft materials	• text messages • video • poster • PowerPoint presentation
2 (N=4)	Designing and implementing craft lessons related to a frame woven textile	Design a frame woven textile	• small group • peer students	Primary school class with • 9 special education pupils • school teacher • 4 personal adult assistants	• Internet materials • books • story • tablets • design software • mobile phones • video • editing software • song	• pen • weaving frame • thread	• email • video • computer • PowerPoint presentation
3 (N=3)	How tablets could be used to document the process of puppet theatre	Design puppet theatre presentations related to the theme of winter	• small group • peer students	After-school club with • 12 pupils • leader of the club	• lectures • tablets • computer • books • photos • Internet materials	• model of a puppet • craft materials	• mobile phones • Facebook • video • PowerPoint presentation
4 (N=3)	How tablets could be used with children, particularly in knowledge searching and documenting activities with children	Search for information about the animal of their interest and craft their own presentations	Small group	After-school club with • 10 pupils • leader of the club	• lectures • models of collaborative learning • tablets • computers • Internet materials • video • editing software	Craft materials	• email • video • interviews • PowerPoint presentation

Table 1. Learning tasks, learning community and use of tools

> inspired by the design and planning, and the implementation was really nice. (Small group 2)

The descriptions of the students' tasks were often connected to the use of tools, particularly tablets. However, the diverse tasks that they gave to the pupils were emphasised as very different objects of activity. Three of the small groups designed highly open-ended learning tasks for the pupils without guidance from the school teacher. Trust in the pupils' agency was also considered challenging: "It is difficult for the teacher to be confident that the goals will be achieved and that the students will learn if they are given a free hand" (Small group 3).

Emerging learning community

The students reported that the small groups were highly active in communication, collaboration and interaction. They negotiated the learning task and inquiry questions and planned together how to pursue them in practice.

This process involved agreeing on common rules for working, creating ideas and lesson plans for the intervention, gathering and producing teaching materials, designing the data collection and presenting the intervention results. The students wrote that they also received support from their peers outside their small group during this process. Interestingly, the university teacher-researcher who was leading the exercises was not mentioned at all in the community resources.

While extending the learning community, the first small group used their existing networks to implement the intervention in a multicultural after-school club, in which one of the student teachers was working. The other groups were creating new relationships in external communities. The expanded learning community within the school and the after-school teachers were discussed a great deal when designing and implementing the intervention. The reports also indicate that the interactions between the students and school teachers were considered mutually fruitful: "We also received positive feedback from the teacher about the story, video and design program. She was satisfied with the lessons and acquired a new perspective on teaching" (Small group 2).

Tools and artefacts

The reports demonstrate that the students used different tools and information resources, e.g., lectures, books and Internet, when given a free hand to design and build their own tool environments. The technologies applied by students in designing the intervention typically included tools for communication and networking; familiar technologies such as mobile phones, Facebook and email were used. When the interventions with pupils were implemented, new technologies were included in the learning environment, particularly tablets that students were not familiar with but were interested in exploring. The students also considered mobile technology easy to integrate when working with pupils in different learning environments. The student teachers aimed to use tablets with their pupils for multiple purposes such as prototyping, craft designing, reflective reporting, giving video instructions, documenting the learning processes and searching for information, materials and resources. In addition, the technology was used in connection with other tools and materials, while different physical tools and craft materials were offered for pupils' design processes. The role of technology in such a process is described in the following example:

> We used the tablets through inquiry learning, and no printed instructions were given…If needed, we advised the pupils on the various functions of the tablet. Tablets were used [by the pupils] in making videos, searching for crafting instructions and playing games; prop masks were made mainly of paper and string. (Small group 1)

Students also appreciated having the opportunity to connect their studies with real-life situations while using new technology in craft education:

> The kids were really excited to use iPads. They already knew how to use them surprisingly well. Some of the children were immensely inspired to make their own videos and take photos with iPads. Organising the intervention was a useful experience for us students, as we are not able to go to the field often, especially using a new kind of technology. (Small group 4)

Discussion

As we have entered the twenty-first century, it has become evident that our students are growing up in rapidly changing world, particularly because of the increasing pace of knowledge development and technological advances. The promotion of inquiry activities that enable students to use diverse knowledge resources, tools and network connections is considered particularly important when solving real-life problems and creating situation-based solutions. According to Barab and Roth (2006), education should connect learners to an ecological system that fuels an appreciation for and a desire to be a part of contexts through which these extended learning networks take on meaning. From this perspective, learning is about connecting as part of an ecosystem, which involves increasing the possibilities for action in the world (Barab and Roth, 2006).

The present study uses the notion of self-organising ecosystems of learning by emphasising that the learning process is not scripted in detail in advance but has to be actively designed by the students themselves. It matters that various resources and connections are available to the students, but it is equally as important that the students are positioned in a key role when defining the specific network of people, tools and information resources in terms of their own intentions and negotiated learning task (Author, 2014). The instructional model, as well as joint activities with peers and community members, should support the students in using, designing and organising the connections, thus increasing the students' levels of expertise (Wertsch, 2007).

The results of this case study provide insights into the experiences of employing technology-mediated learning in teacher education, which applied the instructional principles of LCD. All self-organised small groups came to

have their own learning system and applied different resources to design and implement their technology-mediated learning and teaching. These small group interventions provided different perspectives of the shared learning tasks and brought diverse resources to the dynamic ecosystem of all participants. Consequently, the participation in an extended learning network was driven by the student teachers' interests; they worked together in teams in pursuit of advancing their understanding and sharing it with the extended community (Author, 2014).

The articulation of the shared task can be understood as identifying, negotiating and selecting the resources that become part of the students' learning process (Author, 2014). It included the process of perceiving the function and meaning of the selected resources and making new connections in terms of achieving a particular goal, in relation to the different stages of the process of collaborative design. By focusing on the pedagogical implementation, the students were acknowledging that the same design task could be performed with a range of different physical tools and technologies, and that the same tool could be deployed towards a variety of different ends. As Claxton (2002) argued, if the main thing we know about the future is that we do not know much about it, then the educators should not only provide learners with the tools of today, but should also help them become confident and competent designers and makers of their own tool environments when solving emergent problems.

The results of this study indicate that LCD was a successful instructional model in providing experiences of participatory-evoking and technology-mediated learning, which may be situated in diverse physical, social and technological environments. The study placed a special emphasis on the students' role as active participants, on co-learning as well as co-creation and on using diverse tools for thinking and for collecting, organising and sharing information. Making the emerging connections transparent can also be an important part of the learning portfolio, which helps students and teachers reflect upon their learning and communicate it to the whole collective (Author, 2014).

All studies have their limitations: in this study, the inquiry focused on craft teacher education and was conducted in one university and during one course. For this reason, the research results cannot be generalized to all situations and contexts. However, the results may offer useful information for teacher education and for researchers considering the application of the findings in a suitable context. Mayring (2007) and Blom and Nygren (2010) have suggested that in most cases the targeted conclusions of a qualitative study may be more general than the results found. Nevertheless, more research is needed in the future to make the emerging learning system more visible to the students and other members of the community during the course. Therefore, an interesting future step would be to dynamically track, visualize and share the progress of learning and the growing system during the design project. Future research should also include longer-term studies to further explore the designing of connected learning systems in diverse contexts and target groups.

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