Teaching design of technologies for mediating collaborative interaction - an emerging pedagogical framework

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Abstract
Collaboration is one of the 21st century skills, and in our new digital and hybrid reality, the importance of designing technologies that support collaborative interaction in various ways has increased due to e.g., the recent Covid-19 pandemic and the need to decrease travel to keep down environmental impact and avoid unnecessary contributions to the climate emergency. Accordingly, designers of digital tools need to be educated regarding supporting collaborative interaction, online, on-site and hybrid. However, there is a lack of concrete teaching materials for how to design collaborative technologies. In this paper, we present an emerging pedagogical framework targeting technology design educations in higher education in teaching to develop students' knowledge and skills for how to design technology that mediates collaborative interaction. The pedagogical framework will be made available for everyone as an online open educational resource.

The framework is developed through a pedagogical design pattern method using a three-phased model for conducting educational design research and developing educational materials. The results are based on Laurillard's pedagogical pattern template (Laurillard, 2012), and further extended with the SOLO taxonomy for defining learning objectives (Biggs, 2003). Using one specific approach throughout simplifies consistency and coherence among the various parts. The pedagogical framework consists of 10 pedagogical patterns, which entail concrete teaching activities with accompanying learning goals. The teaching activities are divided into concepts, methods and practices:

Concepts explain the underlying conceptual and theoretical foundations that students need in order to take human collaborative interaction into account, both in their methods and in their design process, as well as in taking responsibility for their end product or service. An example of a teaching activity is a lecture on 'Collaborative interaction in Activity theory'.

Methods address methods for students to engage with groups, elicit requirements for design, and to practically design and evaluate collaborative technologies. An example of a teaching activity is a lecture and exercise on 'Requirements elicitation for collaborative technologies'.

Practices consists of case studies that illustrate best practices and case studies in designing collaborative technologies. An example is a lecture with an accompanying exercise on 'Designing for Collaborative co-located multi-display environments'. Together, these teaching resources, which are all freely available online, make up a framework that supports developing students' knowledge and skills for how to design technology that mediates collaborative interaction.

We believe that this work has two contributions. First of all, to propose what an emerging pedagogical framework for learning about designing collaborative technologies can be and open it up for critique and further development. Secondly, we also believe that a discussion on teaching practices is important in that it can contribute to developing the research field, as students display through their learning process, aspects that would perhaps have been hidden if we studied experienced designers, or only reflected on our own research practice.

Author keywords
Collaboration; design; CSCW; HCI

Introduction
Collaboration is a very complex skill which involves coordination, cooperation and at its most advanced level, reflective communication (Bardram, 1998), and is considered as one of the 21st century skills (OECD, 2018). In a time where remote collaboration has become increasingly more important due to e.g., environmental emergency and pandemics (e.g., Tudor, 2022), the need for designing and developing technologies that efficiently support and mediate collaborative interaction has become a high priority.

Historically, most user interface research has focused on single-user systems, although this has been challenged by multi-user or group interfaces (Ellis et al., 1991), which are sensitive to such factors as group dynamics and organizational structure. Collaborative technologies come with design challenges, such as that technology designed for use by different groups must be flexible and accommodate a variety of team behaviors and tasks (Ellis et al., 1991). E.g., two different teams performing the same task use collaborative technology in very different ways (Rein and Ellis 1989), and the same team doing two separate tasks uses the technology differently for each task.

However, teaching as an activity has been somewhat neglected within fields such as Computer Supported Collaborative Work (CSCW, Brown et al., 2007). This in some contrast to HCI, in which teaching has played a more prominent role, and where textbooks summarize what is to be learnt (i.e. Preece et al., 2019) and there is a lively discussion in the community (e.g. Churchill et al., 2013; Eriksson et al., 2022a; Frauenberger and Purgathofer, 2019), including in various sub-fields (e.g. Child-Computer interaction (Van Mechelen et al., 2020), animal-computer interaction (Zamansky et al., 2017). Teaching technology design for collaborative interaction involves imparting a distinctive attitude – in particular a sensitivity to co-ordination. In this paper we aim to initiate a pedagogical framework for teaching design of technologies for collaborative interaction in higher education. We do so by transforming concepts, methods, and practices from research into concrete teaching activities with accompanying learning goals.

Using the materials presented here for teaching a course on designing collaborative technologies will not make the students become experts, but hopefully they will gain a much deeper understanding of how to engage with understanding a group and a setting, before coming to think about design. This might perhaps be the most important student outcome and a core lesson – the connected nature of the technical and the social. We are aiming for students to 'come to see' collaboratively, and through that develop students' knowledge and skills for how to design technology that mediates collaborative interaction.

Background

In the light of the COVID19-pandemic, it is easy to think of collaborative technologies as primarily communication technologies such as applications to support video meetings (e.g., Grønbæk et al., 2021). However, in this work, we refer to a broader notion, including everything from social drones (e.g., Obaid et al., 2022), digital games (e.g., Eriksson et al., 2022b), to the collaborative society (e.g., Jemielniak and Przegalinska, 2020), just to mention a few.

There are several definitions of what collaboration and collaborative interaction mediated by technologies is (e.g., Bardram, 1998; Correia et al., 2017; Roschelle and Teasley, 1995; Sedano et al., 2013; Shah, 2010). However, terms related to collaboration, such as cooperation, coordination, teamwork, social interaction, etc. are often used as synonyms or interchangeably, and there is no systematization of the terms used (Baykal et al., 2020b; Sedano et al., 2013). For instance, social interaction is a vital but insufficient condition for collaboration because some social interactions do not involve shared goals, accommodation of different perspectives or organized attempts to achieve the goals (OECD, 2018).

However, recently, we have seen a tendency to adopt the levels of collaboration as defined in Activity Theory (AT), in order to define collaboration in an operational way (Bardram, 1998; Baykal et al., 2020a; Eriksson et al., 2021). AT provides a method of understanding and analyzing a phenomenon, finding patterns, and making inferences across interactions (Kaptelinin and Nardi, 2009). With AT as a theoretical foundation, Engeström et al. (1997) defined three levels of collaborative interaction, and building on this definition, Bardram (1998) introduced a framework for collaborative interactions between users and mediating technology. This framework consists of three different levels of collaboration, from the simplest to the most complex form: Coordination, Cooperation and Reflective Communication. Acknowledging that there are many other models for defining collaboration, we will in this work lean towards the three levels of collaboration as deriving from Activity theory (Bardram, 1998; Engeström, 1987).

What do we mean by collaborative technologies?

The goal of collaborative technologies, or collaboration systems or groupware, is to assist groups in communicating, in collaborating, and in coordinating their activities, and can be defined as: computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment (Ellis et al., 1991). In the classic CSCW matrix (Johansen, 1988), four main areas of collaborative technologies are presented:

Face to face interactions: Collocated social interaction focuses on scenarios of 'same time, same place', that is, a synchronous interaction between individuals in close proximity, e.g., single display groupware. In synchronous interactions, such as spoken conversations, people interact in real time (Ellis et al., 1991). In technology development, this area has attracted less interest than technologies for remote connectedness, and hence remains less explored and characterized (Olsson et al., 2019).

Remote interactions: Focus on same time, different place and a typical technology is video conferencing. This is an area that has received increased attention lately, not least due to the COVID-19 pandemic (Tudor, 2022).

Continuous task: Focus on different time, same place, and typical examples are team rooms and large public displays. Interactions are asynchronous, meaning those in which people interact over an extended period of time (Ellis et al., 1991).

Communication and coordination: Focus on different times, different places, where typical examples are email and group calendars.

However, there is one area missing in the matrix, namely that of technologies to support *hybrid interaction*. Neumayr (2021) presents a systematic literature review of the contexts and tools of hybrid collaboration and meetings in HCI and CSCW, with the goal to unpack how hybridity matters when it confers an asymmetry on the coordinated activity. In this review, hybrid collaboration refers to *"collaborative practices that involve simultaneous co-located and remote collaboration with phases of both synchronous and asynchronous work that spans multiple groupware applications and devices"* (Neumayr et al., 2018) and hybrid meetings refer to video- or audio-based communication sessions among co-located and remote participants (Roussel and Gueddana, 2007). Hybrid collaboration switches back and forth between all four quadrants of the time-space matrix. There are constant transitions between co-located and remote as well as synchronous and asynchronous collaboration. Further, users typically do not rely on a single groupware application or hardware device but simultaneously use different tools and devices during collaboration. Also, the team size is greater than just two collaborators and multiple coupling styles can coexist simultaneously within a single team, effectively dividing the whole team in multiple temporary subgroups of various sizes and an individual coupling style (Neumayr et al., 2018).

Although many systems can be categorized according to their primary emphasis and intent (Ellis et al., 1991), it is important to note that there is no rigid dividing line between systems that are considered collaborative and those that are not, or belonging to one category of the matrix or not. Due to the varying degrees of support for common tasks and shared environments, it is more appropriate to think of a collaborative technology spectrum rather than well-defined boxes (Ellis et al., 1991). In the work presented in this paper, we apply this thinking of collaborative technologies as a spectrum with constant transitions in time, space, and level of collaboration.

Methodology

A three-phased model for conducting educational design research and developing educational materials (McKenney and Reeves, 2018) was used as an underlying and guiding research and development framework. Educational design research is aimed at providing concrete solutions to educational practitioners in relation to practical and complex educational problems such as how teachers can teach collaborative interaction in technology design. Solutions can take the form of educational products and materials that both support teachers in their educational practice and seek to discover new knowledge that can inform future research, development, and practice within that domain.

Phase 1) Exploration and analysis

Exploring the existing domain of teaching design of collaborative technologies by firstly making an inventory of existing teaching practices and research production at our own universities. Secondly, by conducting a literature review on (teaching) design of collaborative technologies and through this developing the research grounding. This included e.g., searching SCOPUS for (TITLE-ABS-KEY (cscw) AND TITLE-ABS-KEY (teach*)), in which we found 135 results, but only one (Brown et al., 2007) actually addressing teaching collaborative technologies. In this phase we also invited two experts and interviewed them on their teaching practices in regard to designing collaborative technologies. We further snowballed on further research resources to include.

Phase 2) Design and construction

Based on phase one, two/three core competencies were identified, and a number of overarching learning objectives were extrapolated and described. Then the SOLO taxonomy (Biggs, 1982) was applied to the competencies and learning objectives to describe how we as teachers can develop students' competencies from a beginner to an advanced level. This led to the construction of an overarching model for how teachers can plan, carry out and evaluate teaching and learning on designing collaborative technologies. Based the results from the first phase, and on the core competencies and learning objectives, we developed a number of concrete learning activities consisting of lectures and exercises.

Phase 3) Evaluation and reflection

Alongside the design of the stand-alone teaching activities, an iterative peer-review of all activities was carried out using the pedagogical pattern evaluation method called shepherding (Harrison, 1999). This method ensured multiple cycles of evaluation, reflection, and revision of the activities throughout the project. Additionally, the teaching activities were put into practice and evaluated through 30 pilots involving around 40 teachers and 523 students coming from various disciplines, programs, institutions, and educational contexts in five universities in four different countries. After each pilot, the teacher was asked to fill out a questionnaire. The students involved in the pilots have been enrolled in bachelor (n=14 pilots), master (n=5 pilots) and mixed PhD \& master programs (n=11 pilots). The programs range from communication design (Faculty of architecture and design) to interaction design (Department of computer science), digital design (Faculty of Arts), Design, Technology and Society Program (Institute of Social Sciences), Design, Technology and Society Program (Institute of Media and Visual Arts), and experience economy (Faculty of Arts).

Pedagogical design pattern approach

The main outcome of the project – the collection of teaching activities – was developed using a modification of the pedagogical design pattern method (Goodyear, 2005; Köppe et al., 2017; Laurillard, 2012; Nørgård et al., 2019). The method is aimed at capturing "best practices" from research and practice, which are then developed into concrete activities for teaching and learning within a specific domain.

The pedagogical pattern method has been applied in order to elicit existing best practice from teachers and from related work found through snowballing. The method has been modified in that we have iteratively developed our own pattern template highly inspired by the pattern template suggested by Laurillard (2012) with the main difference that the students' learning objectives are formulated based on the SOLO taxonomy for defining intended learning outcomes and objectives (Biggs, 1982), for consistency and shared language. The template is complemented with teaching materials, such as suggested literature, worksheets, assignments, and presentation slides. Additionally, all visuals and figures in the developed teaching material are either private images with consent to be published from the owner or generated using artificial intelligence (DALL-E).

The pattern template consists of the following items (Italicized items are modifications from the original template prosed by Laurillard (2012):

- *Title* (Title of the pattern).
- Origin (the original source and later contributors).
- Summary (brief description of what is being taught and how).
- Topics (keywords that will help other teachers decide the relevance).
- Learning outcome (what the learner will know or be able to do by the end *defined using SOLO taxonomy*).

TITLE	Requirements elicitation for collaborative technologies			
ORIGIN	TEDCO			
SUMMARY	Requirements elicitation is about exploring the problem space and defining what will be developed. Requirements range from functional to contextual such as e.g. social environment and user goals. Methods for gathering and analyzing data to elicit requirements will be presented and practiced.			
TOPICS	Methods for requirements elicitation, qualitative data analysis and evaluation			
LEARNING OUTCOME	• Students should be able to name methods for requirements elicitation and qualitative data analysis for collaborative technology. • Students should be able to formulate requirements for collaborative technology. • Students should be able to apply requirement elicitation in design of collaborative technology. • Students should be able to evaluate requirements in the design of collaborative technology.			
RATIONALE	Experiential learning; learning through practice.			
DURATION	3h			
LEARNERS	Design and engineering in higher education			
SETTING	Online, face-to-face, hybrid			
RESOURCES AND TOOLS	Slides in .ppt with lecture and assignment			
LEARNING CYCLES	Sequence of teaching–learning activities	Group Size	Time Mins	Code
	The teacher introduces students to relevant factors for eliciting requirements from qualitative data when designing collaborative technologies. Explains how they will be advised and evaluated	All	40	TCC1
	Students in groups practice analysis of qualitative data and/or requirements elicitation.	4	60	TPC1
	The teacher checks what the students are doing, and advises on aspects to consider.	4	3	TPC2
	The students share their practice outputs with peers, and gain access to peers' outputs as a model for their practice.	8	20	PMC1. 2
	The teacher chairs a class discussion, asking for reflections on experiences, and consolidating the lessons learned.	All	30	PCC1, 2, 3

Figure 1. Example of a completed pattern template - here for Requirements elicitation.

» Rationale (the learning approach or pedagogical design principle).
» Duration (total learning hours, not necessarily continuous).
» Learner characteristics (educational pre-requisites, experience, interests)
» Setting (face-to-face, blended, or online).
» *Resources and tools (the teaching materials e.g., lecture slides).*
» Group size (the range of minimum to any maximum).
» Learning cycles (Sequence of teaching–learning activities)

For the learning cycles, the following codes are used:

» Formative assessment FA
» Summative assessment SA
» Design elements for activities in the Conversational Framework Cycles Access to the teacher's concepts TCC1
» The means to articulate their concepts and reflections on practice TCC2
» Extrinsic feedback on questions or articulations of their concepts TCC3
» A practice environment that facilitates their actions TPC1
» Extrinsic feedback on their articulations of their actions TPC2
» A modeling environment that elicits their actions TMC1
» Intrinsic feedback on their actions from the model TMC2

Figure 2. The pedagogical framework for teaching design of technologies that mediate collaborative interaction. The framework is centred around the overarching learning objective, and consists of three parts: teaching activities, learning objectives, and concepts, methods and practices.

» Access to peers' concepts PCC1
» The means to articulate their concepts and reflections on practice PCC2
» Extrinsic feedback from peers on articulations of their concepts PCC3
» Sharing practice outputs with peers PMC1
» Access to peers' outputs as a model for their practice PMC2

For an example of a complete teaching pattern, see Figure 1.

Results

The overarching learning objective of the entire pedagogical framework is: *To develop student's knowledge and skills for how to design technology that mediates collaborative interaction*, see Figure 2. In order to strive for this learning objective, the teaching activities that the framework consists of are divided into concepts (Table 1), methods (Table 2), and practices (Table 3), each with its own learning objectives and pedagogical pattern. The teaching materials are available for download at https://www.tedco.se.

Considerations for applying the pedagogical patterns

The collection of teaching activities presented in the framework above is meant as an inspirational educational resource, where it is possible to pick and choose what is needed, and what fits into the existing curriculum. They are not designed for a specific curriculum or meant to be taught together as a course. However, there are many considerations to take when planning to teach about design of collaborative technologies including: Who are the intended students, and what curriculum are they following (computer science, engineering, social science)? Length of learning activity (workshop, full course)? Level of knowledge of the students in relation to designing collaborative technologies (beginner or more advanced)? The dimensions of knowledge, skills and attitude that need to be taught (awareness of aspects of collaborative technol-

Table 1. Overview of Concepts in teaching design of collaborative technologies.

Concepts in Design of Collaborative Technologies
The core concepts of collaborative technologies which are relevant for design research and practice, and what are the strategies to link these theory and concepts to design practice. Explains the underlying conceptual and theoretical foundations that students need in order to take collaborative interaction into count, both in their methods and in their design process, as well as in taking responsibility for their end product or service.
Learning Objectives
• Recognize and describe different aspects of collaborative interaction. • Analyze and critically reflect on how collaborative interaction is mediated by technology design
Pedagogical Patterns
• **Introduction to designing collaborative technologies.** Summary: The students are introduced to designing technologies that mediate collaborative interaction. This includes examples of technologies that mediate collaborative interaction, the elements that make up collaborative interaction, and various levels of collaborative interaction. • **Collaborative Interaction in Activity Theory.** Summary: The students are introduced with theoretical approaches and paradigms related to collaborative interaction mediated by technology. Students describe different aspects and levels of human collaboration mediated by technology. Topics for the final discussions is on how students would want to modify the systems to increase or enhance the current collaborative interaction.

Table 2. Overview of Methods in teaching design of collaborative technologies.

Methods in Design of Collaborative Technologies
The methods and approaches for understanding, investigating, and designing technologies for collaborative interaction. Addresses methods for students to engage with groups and their collaborative interaction mediated by technology design, and also to practically design and evaluate collaborative technologies.
Learning Objectives
• Identify and describe direct and indirect stakeholders of a collaborative technology design. • Elicit stakeholder requirements for collaborative technologies. • Integrate considerations for collaborative interaction into the design process. • Analyze, evaluate and critically reflect on the impact of a technology in collaborative interaction in context
Pedagogical Patterns
• **User research in designing collaborative technologies.** Summary: The students are introduced to relevant factors for performing field research when designing collaborative technology (distinctions from dyads to communities), three types of methods to achieve it (ethnography, artifact ecology, and network analysis). • **Requirements elicitation in designing collaborative technologies.** Summary: Requirements elicitation is about exploring the problem space and defining what collaborative technology will be developed. Requirements range from functional to contextual such as e.g., social, environment and user goals. Methods for gathering and analyzing data to elicit requirements for collaborative technologies will be presented. • **Evaluation of collaborative technologies.** Summary: The students learn how to evaluate the user experiences with the system. Students list the methods of evaluating user experience, and propose which method works best for their own system. Students also reflect on why studying user experiences is important, and in which phases of the design process this can play a meaningful role.

ogies, methods for practicing design of collaborative technologies)? When aiming for the overarching learning objective, the framework can be used in several different ways, see Figure 2. For instance, teachers can *explore the learning objectives* for each activity and select those that are the most relevant to their discipline, curriculum, or course. The learning objectives are described in broad terms, while the teaching

Table 3. Overview of Practices in teaching design of collaborative technologies.

Practices in Design of Collaborative Technologies
The practices and pedagogies highlighting how design problems related to collaborative interaction mediated by technology are more uncertain, more nuanced, or more complex than originally assumed. This complexity will be unfolded through a number of case studies. Consist of case studies that illustrate practices in designing collaborative technologies.
Learning Objectives
• Recognize, design, and analyze relevant factors for the design and collaborative aspects of multi-display environments. • Recognize, describe, and analyze relevant factors for the design of technologies for co-located interactions. • Recognize, describe, analyze and integrate hybrid collaboration aspects in the design of collaborative technologies. • Recognize and describe relevant taxonomy for extended reality and analyze aspects in synchronous extended reality remote collaboration systems. • Recognize and describe different aspects of collaborative society
Pedagogical Patterns
• **Designing for Collaborative co-located multi-display environments.** Summary: The students are introduced to the concept of multi-display environments (MDE), i.e., the coupling of several displays together to form a shared interactive environment. The concept is described through a framework and illustrative cases. • **Designing for Mobile and co-located collaborative interaction.** Summary: The students are introduced to designing for co-located collaborative interaction mediated by technology. A framework for designing co-located mobile interactions is presented that can be a useful tool for work in this area. • **Designing for collaborative interaction in hybrid settings.** Summary: The students are introduced to relevant factors for recognizing, analyzing and designing technology to support hybrid collaborative interaction, while reflecting on the consequences of the technologies. This includes understanding how hybridity matters to the tools and processes of collaboration and unpack how hybridity matters when it confers an asymmetry on the coordination that occurs within the interrelated concepts of collaboration. • **Designing for collaborative interaction in extended reality environments.** Summary: The students are introduced to the taxonomy for synchronous collaborative interaction in social augmented, mixed or virtual reality platforms. This includes understanding the main components for designing extended reality platforms that mediate collaboration. Opportunities and challenges of future virtual systems for collaboration are presented for future design considerations. • **Collaborative society.** Summary: Introduces to collaborative society, an emerging trend that changes the social, cultural, and economic fabric of human organization through technology-fostered cooperative behaviors and interactions. This includes different modes of cooperation, illustrated by examples such as sharing economy, peer production, social activism, internet of things, big data etc.

activities connected to each of the learning objectives execute them in concrete ways. Further, teachers can *combine concrete teaching activities* that move students from a simple (unistructural) to a complex (extended abstract) level of understanding of designing collaborative technologies in accordance with the SOLO taxonomy Biggs (2003). Teachers can also *combine concepts, methods and practices* that create a broad foundation for students to become designers of collaborative technologies. Whatever way is chosen, it is important for teachers to adapt and appropriate the teaching activities to fit their specific educational context (Hendry, 2020; Nilsson et al., 2020).

Experiences with using the teaching materials

The teaching materials were iteratively developed based on the peer-review process but were also evaluated based on a questionnaire by the teacher after pilots. Some of the teachers gave concrete input to further development and design iterations of the teaching materials, such as a pilot using the Evaluation pattern, where the teacher states that 'the pattern on Evaluation should be split up into multiple parts'. Also, when the teaching material on stakeholder mapping was tested in a bachelor project course, the teacher comment that 'the workshop gave insights into the topic that could be taken into account in the further developments of the material, and that in general students tend to be well able to grasp 2x2 matrices in various contexts (not only placement of collaborative technologies, but also types of stakeholders could be classified in a 2x2 matrix)'. The teachers state that the added value of the piloted teaching material was: 1.) professional development within technology design for collaborative interaction, 2.) a qualitative update of the design curriculum of collaborative technologies, 3.) increased capacity to teach technology design for collaborative interaction in relevant and innovative ways.

Discussion

The pedagogical framework presented in this paper is the result of an inductive approach to the pedagogical pattern method, meaning that we started with our own and our colleagues research and teaching practices, and snowballed from there. This means that we are not trying to claim that this framework covers everything a student needs to know in order to develop knowledge and skills for how to design technology that mediates collaborative interaction. Rather, this is an initial approach to an emerging pedagogical framework. We are not claiming that an inductive approach is the best or only approach possible, a more deductive approach could have led to a different outcome. Also, the evaluation of the developed teaching material is so far restricted to iterative peer-review and questionnaire feedback from teachers after pilots. In future work, we would encourage further evaluation based on feedback from students, and not only rely on the teacher's conception based on the students observable learning.

Challenges and considerations

In this work, we have met a number of challenges and considerations that we need to pay attention to when designing teaching materials for the design of technologies that mediate collaborative interaction. The first issue is the lack of a common definition for collaboration. The term "collaboration" used interchangeably with similar but not synonymous words such as "social", "cooperative", "coordination" in the literature especially in technology design studies (Baykal et al., 2020b). Thus, in our teaching materials we adopted the following formulation for the term collaboration in order to identify the elements of collaborative interaction Collaboration is a technologically mediated social interaction between multiple people who share a common goal. Based on this formulation of the term, the core elements of the collaborative interaction include; Social (synchronous or asynchronous), Multiple people (human), Those people have a shared goal, Technology plays a mediating role between multiple people, Intention of designers and/vs. users' appropriation.

The second issue is also linked to the first one in that collaboration is a very complex phenomena which is not only difficult to define but also to analyze. To this extent, we found the levels of collaborative interaction defined in Activity Theory as the most comprehensive one. Derived from Activity Theory, Engeström defined three levels of collaborative interaction: 1. coordination, 2. cooperation, 3. reflective communication (Engeström, 1987; Engeström et al., 1997). This definition inspired some work particularly in CSCW (Kuutti and Arvonen, 1992) as well as in HCI in general by being used as a lens to analyze the collaborative interaction mediated by technology (Kaptelinin and Nardi, 2009; Kuutti et al., 1996; Bardram, 1998; Baykal et al., 2020a), albeit having its own limitations (Bødker et al., 1988). The future work may use the definition to analyze the collaborative activities in different scales (e.g., business models such as Uber, Airbnb which were built on shared economy as explained from a critical theoretical perspective in Collaborative Society by Jemielniak and Przegalinska), spaces (e.g. hybrid meetings, see Neumayr et al. 2021; Grønbæk et al. 2021), or realities and temporalities (e.g. envisioning and designing various interaction modalities and sensory inputs which require further investigation in social AR/VR/MR platforms (Schäfer et al., 2021).

The third issue is sort of an outcome of the former two in that the lack of a common definition and level of complexity of the phenomena for analysis yields a diverse but scattered knowledge of how to design for and evaluate the collaborative interaction (Baykal et al., 2020b), let alone the challenges in mediating a higher level of collaboration between the collaborating actors.

Intention and adoption in the design of collaborative technologies

In this framework, collaborative technologies are considered as a spectrum with constant transitions in time, space and level of collaboration. This is due to the fact that there is no rigid dividing line between systems that mediate collaborative interaction and those that do not. Many systems can be categorized according to their primary emphasis and intent (Ellis et al., 1991), but still most often have varying degrees of support for common tasks and shared environments and is also highly dependent on the specific adoption by the users in specific situations. So, this is why we in this work find it more appropriate to think of a collaborative technology spectrum rather than well-defined boxes, as in e.g., the CSCW matrix (Ellis et al., 1991). This, however, led to difficulties when designing the teaching materials, as the literature more often has a focus on the intention rather than actual use.

Another related challenge we experienced when developing the teaching material, especially when focused on practices, was that most literature has an emphasis on a specific technology or application, and not on the collaborative aspects as such. This led to many discussions on what is specific to designing technologies for mediating collaborative interaction, with the consequence of that much material has been excluded for being classified as too general. Examples of this are general theory on HCI for the pattern "Collaborative Interaction in Activity Theory", and even a whole pattern on "Prototyping collaborative technologies" was excluded.

Methods used

Applying the pedagogical pattern method worked well for the development of the teaching materials presented in this framework. Especially the use of the SOLO taxonomy as a shared language for defining learning objectives was experienced as very fruitful. The SOLO taxonomy became a shared language not only for the design team, but also in correspondence with the teachers involved in the pilots, as they are used to SOLO in their practice. In regard to the pattern template inspired by Laurillard (2012), especially the learning cycles were highly useful in developing the teaching materials. The sequence of teaching-learning activities helped to provide at the same time a holistic and detailed take on the various materials, so that the lecture and exercises became better aligned.

Conclusion

In this paper, we have introduced an initial pedagogical framework for teaching design of technologies that mediate collaborative interaction. The framework is based on an inductive approach to the pedagogical pattern method in combination with the SOLO taxonomy. The framework is a first try to transfer concepts, methods and practices from research into concrete and inspirational teaching activities aimed for teaching in higher education. In the framework, collaborative technologies range across many different application areas, and without a well-framed definition. Still, the core elements include social interaction (synchronous or asynchronous), Multiple people (human), Shared goal, Technology as mediator between multiple people, Intention of designers, and User appropriation. In the framework, collaborative technologies are considered as a spectrum with constant transitions in time, space and level of collaboration. Hopefully this framework can inspire teachers in higher education to dive into the complex world of teaching in designing technologies for mediating collaborative interaction.

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