Computer Supported Cooperative Work (CSCW) (2020) 29:743–767
DOI 10.1007/s10606-020-09378-w

Unpacking the Role of Boundaries in Computer-Supported Collaborative Teaching

Sara Willermark* & Lena Pareto
*Division of Media and Design, School of Business, Economics and IT, University West, Gustava Melins gata 2, 461 32 Trollhättan , Sweden (sara.willermark@hv.se, lena.pareto@hv.se)

Abstract. In this study, we explore the role of boundaries for collaborative learning and transformation of work practices to occur. We report from a three-year action research project including well over 1800 h of participation by the authors. The empirical data are based on project participation work including observations and field notes, project reports, interviews and a questionnaire, within a school development project in Nordic elementary school. In the project, teachers and researchers from three Nordic countries, Norway, Sweden and Denmark, collaborated to develop novel, on-line teaching models for a Nordic Virtual Classroom. The virtual classroom refers to an educational setting where teaching and learning activities are conducted collaboratively in cross-national teams "in the cloud" by means of information technology. During the project, teachers were challenged in their current teaching practices and the project resulted in collaborative learning and transformation of work practice. In this paper, we explore underlying reasons for such transformation to occur by unpacking how and why boundaries can play a role in computer-supported collaborative teaching and stimulate a transformation towards digitalized teaching practices. The paper contributes with an explanation of how the composition of boundaries of a technological, organizational, and cultural nature operates and constitutes a resource for learning and principles for how boundaries can be used for such purpose.

Keywords: Boundaries, Digitalization, Teaching practices, Virtual classroom, Work practices

1. Introduction

Research within computer-supported cooperative work (CSCW) is concerned with collaboration among people supported by technology. The focus has persistently been on people, practices, and technologies, as forming complex constellations that enable collaboration, or hamper it (Kinnula et al. 2018). In fact, this research topic is more relevant now than ever, as geographically distributed organizations and networks are steadily increasing their use of technology to support collaboration across distance. Due to increasing specialization in work, people search for ways to connect across social and cultural practices to avoid fragmentation of work, and in these situations boundaries become an issue (Hermans and Hermans-Konopka 2010). Furthermore, societal changes such as digitalization requires changed organizations and development of professional practices. In the light of digitalization, the school as an organization and teachers as professionals has become particularly debated.

Teachers face a situation with demands to transform their (digital) teaching practice, yet it is not specified what such transformation constitutes. Probably because no one has the answer, since technology introduction in school as well as in society at large, has taken paths that no one has been able to predict with any greater precision (Grönlund 2014). Thus, there are no given answers guiding the transformation, and such transformations require what Engeström (2001) describes as "expansive learning": With more radical changes in organizations, individuals need to learn new forms of activities and develop new types of work practices that are "literally learned as they are being created" (Engeström 2001, p. 38). This describes current situations with digitalization in many schools today. Many researchers have come to recognize that boundaries challenge established practices and carry learning potential (Engeström 2001; Engeström and Kerosuo 2007; Johannessen and Ellingsen 2009). Here, a boundary refers to a "sociocultural difference leading to discontinuity in action or interaction" (Akkerman and Bakker (2011:133), and can be rooted in for example cultural or organizational differences. Research within various fields has highlighted the complexity of working and sharing knowledge across boundaries (Hall-Andersen et al. 2014; Carlile 2004; Randell et al. 2011). At the same time, the multiple voices meeting at boundaries can trigger dialogue and negotiation, which can explain why confronting boundaries is recognized as not only challenging but also worthwhile to explore in relation to learning (Akkerman and Bakker 2011). Other studies address boundaries in learning (e.g. Edwards and Fowler 2007; Engeström 1995; Engeström and Sannino 2010; Heracleous 2004; Lamont and Molnár 2002). Yet, the literature review on boundaries (Akkerman and Bakker 2011) revealed that the exact mechanisms taking place at boundaries are seldom specified, and the authors urge researchers to explicate how and in what way boundaries can support learning and transformation of practices. In this study, we explore the role of boundaries in computer-supported collaborative work in schools with the aim to transformation the teaching practices for a cross-boundary setting. At start, the term cross-boundary mainly referred to working across national borders, but the term came to embrace several other boundaries as well, as this paper will reveal. Our study is based on a three-year school development action research project in elementary school context aiming to develop novel teaching practices in a collaborative, virtual classroom by means of technology. In the project, teachers and researchers from three Nordic countries, Norway, Sweden and Denmark, collaborated to develop novel, on-line teaching models for the so-called Nordic Virtual Classroom, where cross-national teaching and learning activities are conducted "in the cloud" by means of information technology.

The literature often stresses the importance of challenging teachers in their beliefs about teaching for professional development to be successful (Harland and Kinder 1997; Timperley 2007). In our study, the participating teachers faced a new situation that challenged their beliefs as well as their established practices. The project resulted in a transformation of teaching practices, as reported in previous papers (Pareto and Willermark 2018; Willermark and Pareto 2015; Willermark et al. 2016). Initially, the

collaboration was rather superficial, perceived as too time-consuming while returning little added value as pedagogical teaching models. Also, the planned teaching models were hard to realize in practice in the virtual classroom. However, as the collaboration proceeded, the interaction developed from being vague, confronting and rather superficial towards a shared computer-supported cross-boundary teaching practice, where the differences instead led to interesting subject-related discussions that were used to improve the teaching. Teachers experimented with new collaborative teaching methods and gradually found new innovative ways to use digital technology in their teaching. The teacher community as a whole learned during the project how to conduct this new type of cross-boundary teaching in a productive manner, and that is what we refer to as the cross-boundary teaching. In this study, we explore this transformation process further focusing on the role of boundaries. Several different types of boundaries emerged as vital mechanisms both in terms of obstacles causing conflicts in the collaboration but also as leverages for teacher learning and practice transformations. The aim is to understand how boundaries play a role in learning processes. The research question is: *How and why can boundaries play a role in computer-supported collaborative teaching and stimulate a transformation towards digitalized teaching practices?* While the research setting is a Nordic school development project, the research has broader theoretical implications, as it explicates the role of boundaries in computer-supported collaborative work development.

2. Related Research

Despite being a well-established research area, there are current issues to be explored. For example, recent research addresses the design and use of collaboration technologies in other settings and practices, such as in medicine (Islind et al. 2019), in homecare (Bratteteig and Eide 2017), in industry (Lewkowicz and Liron 2019) and in public sector (Weise et al. 2017). The potential of using technology for collaboration to bridge boundaries is described as almost unlimited and the expectations are often high. At the same time, it is well known that mediated collaboration comes with challenges that add complexity to the work process (cf. Bannon and Bødker 1997; Bradner and Mark 2002; Larsen-Ledet and Korsgaard 2019). Therefore, it is interesting to explore the role of boundaries in the context of computer-supported collaborative work. In their literature review from 2011, Akkerman and Bakker identify four ways in which working across boundaries can become mechanisms for practice change: a) *identification*, which is about becoming aware of the diversity in relation to one other b) *coordination*, which is about forming cooperative and routinized exchanges between practices c) *reflection*, which is about expanding ones' perspectives on the practice that informs future practice and d) *transformation*, which is about co-development of new practices. In previous research, attention has been drawn on various kinds of boundaries, such as physical, technological, organizational, institutional, and geographic borders. For instance, following patient

trajectories as work crosses institutional boundaries (Randell et al. 2011), pursuing mobile work (Nilsson and Hertzum 2005), analyzing individual worker's personal social networks (Nardi et al. 2002), and exploring relationship work in 'war room' meetings for global engineering (Bjørn and Lars Rune 2011). Most studies explore the role of boundaries within organizations, focusing on how professionals with different expertise, tasks or backgrounds collaborate during work (Barrett and Oborn 2010; Broberg and Hermund 2007; Johannessen and Ellingsen 2009). The focus in these studies is on inter-professional collaboration and do not involve collaborative technology. There are other studies addressing cross-boundary settings involving technology. For example, the work of Constantinides (2012) studied technology-mediated cross-boundary and inter-professional work in a private hospital. In their study, boundaries are discussed from the perspective of how they affected inter-professional group dynamics but did not discuss the role for learning. Our work focuses instead on intra-professional work in the context of computer-supported collaboration across national borders within teaching. Teachers like other professionals need to respond to emerging challenges of societal demands by developing relevant competences and ways of working to maintain professional capacities (Billett and Choy 2013). As technology becomes more powerful and portable, it changes the conditions for both teaching and learning, and brings an increasing complexity to the teaching profession (Koehler and Mishra 2013).

3. Research Approach

The empirical case is a three-year school development action research project in an elementary school context. The methodological approach is an case study, including complementary forms of data collection as suggested by Koh et al. (2017). It has been highlighted that the methodological choice of a case study highly depends on the object to be studied (Stake and E. 1995), and is therefore more relevant to discuss as an approach to study a specific phenomenon in a real-life context (Islind et al. 2019; Yin Robert 2017), which is unique in some sense (Walsham 1995). Here, the uniqueness is the cross-boundary virtual classroom setting, the volume of participation, and the focus on the mechanism of boundaries that come into play during the computer-supported collaborative teaching.

3.1. The Empirical Case

The project consisted of schools, teachers, and researchers from Norway, Sweden and Denmark that collaborated to develop novel teaching models for a Nordic Virtual Classroom. In total, there were 66 participating teachers from 13 schools in 7 municipalities in the three countries and more than 1000 students and 32 researchers involved. The involved school classes ranged from grade 5 to grade 9 in four different school subjects: native language, social science, natural science and mathematics. The overall idea of the project was to organize all participants in small

cross-boundary teams, involving participants from at least two but preferably all three countries. There were cross-national teams of researchers, school leaders, IT pedagogues, teachers, and students. The researchers were organized according to their specialization in the school subjects and technology use for learning. For this paper, we have studied 11 cross-boundary teams and their teaching over the three-year project duration. The studied teams were from all four subjects and each team consisted at least one but often a few teachers and researcher from each country. The aim of the teams were to learn how to work together with their Nordic colleagues and their respective students in a virtual classroom using technology in their respective subjects. The project had an open-ended goal: to conduct teaching in the virtual classroom where the cross-boundary collaboration provided additional value to the learning situation compared to in-class, traditional teaching. Teachers were primarily responsible for the teaching activities, and owned the core activity of the project. Researchers had the primary role of supporting teachers in this new setting so interventions were based on teacher needs. Researchers were also responsible for documentation, reports, analysis and research contributions. There was one researcher for each school subject, one for IT pedagogy, and one for leadership coordinating and responsible for the respective themes. Furthermore, researchers acted as discussion partners while innovating and evaluating teaching or evaluating technology use. The role division is described further in Table 1 below.

To reach the aim of the project, an iterative process of exploring and evaluating new teaching models in a successively growing community was used. First, a pilot group of teacher teams engaged to develop, share and evaluate new cross-boundary

Table 1. Action research role division between researchers and practitioners

Roles	Researcher	Teachers
Inspiration	Ideas from research	Ideas from practice
Collaboration	Partner for discussions, planning, reflection	
Critical friend	Challenge practice	Challenge theory
Teaching design	Suggest novel teaching models	
Planning	Support planning	Plan teaching models
Teaching	Occasionally assist teaching	Conduct teaching models
Pedagogical Evaluator	Evaluate conducted teaching models	
Technical evaluator	Evaluate used technology	
Analysis	Analyse processes, methods, teaching activities, student work	Analyse teaching activities, student work
Research	Develop methods and models	
Documentation	Document meetings, planning, project activities, evaluations	Document teaching plans
Information	Spread research, project results	Spread project results

teaching models. Here a teaching model denotes a delimited unit of teaching including planning, implementation and evaluation of a specified learning tasks acted out in practice, also referred to as didactic designs (Pareto and Willermark 2018). Then, for each year when novel and promising teaching models were developed and evaluated, the community of teachers grew as the project proceeded. Experiences and lessons learned were regularly shared within the project community via the yearly project conference and yearly project reports, as well as in more frequent meetings with various national constellations. The kernel of the project was however continuous efforts to plan, implement, and evaluate teaching models in iterative cycles. In the *planning phase* (Fig. 1), new and preferably innovative teaching models were negotiated and planned in the respective cross-boundary teams, mainly in online meetings via videoconferencing and in asynchronous communication via e-mail. In the *implementing phase* (Fig. 2*)* the planned for teaching models were to be carried out according to the plans. In the *evaluation phase* cross-boundary reflection sessions with teachers and researchers were carried out in online meetings discussing outcomes and quality of teaching.

Many different technologies were explored and used for the cross-boundary teaching during the project. For communication, the recommended technology was a Project Groupware, but the cross-boundary teams also used e-mail, closed Facebook groups, chat and videoconferencing to manage their internal communication. For the student work, many different digital tools and platforms were explored such as blogs, wikis and Minecraft. Since teachers were free to experiment with any technology that was available to them, there were variations between the teams. In addition to virtual communication, project conferences were organized once a year where all project participants could meet face-to-face.

In accordance with the action-oriented approach, the researchers' goal was to contribute to research as well as practice. To guide the work, the research ethical

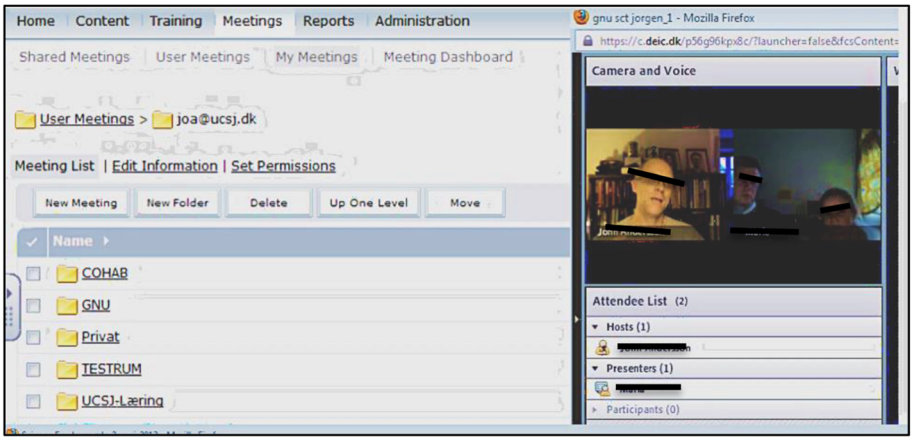

Fig. 1. Illustration of Nordic teachers planning meeting in the virtual classroom using videoconference system

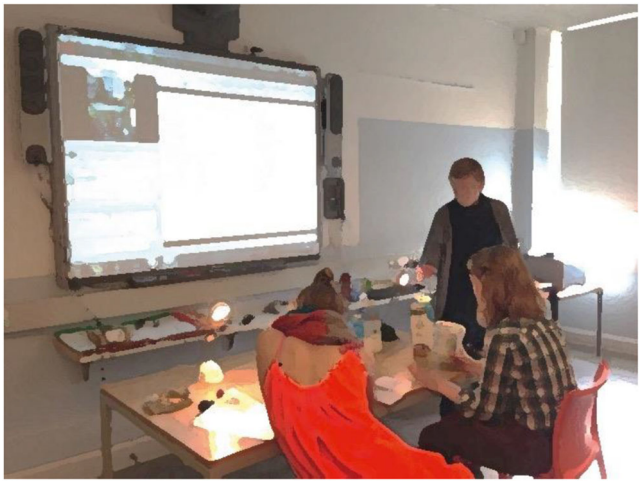

Fig. 2. Illustration of teaching and learning in the virtual classroom, synchronous communication between Swedish and Danish teachers and students

principles for humanistic and social science research from the Swedish Research Council have been applied (Vetenskapsrådet 2002). These principles include the information requirement, the consent requirement, the confidentiality requirement and the use requirement. To ensure informed consent, a letter was sent to all participating teachers and students within the project, with information about the purpose of the research. Since the students were under the age of 15, their parents or guardians also approved and signed a written consent. However, qualitative studies tend to develop in a way that cannot be fully predicted (Miles and Michael Huberman 1994), why it may be difficult to provide complete information from start. For our part, this has been considered by reporting on results and publications through continuous discussions with teachers, through organized project meetings and in the final reporting of the project. We have avoided publishing information that may reveal the identity of the participants, or when pictures are used without masking a consent has been obtained. Finally, the material has not been used for commercial or other non-scientific purposes.

3.2. Data Sources

Since the aim of this paper is to explore the role of boundaries as a mean to achieve a behavioural change, we need to identify situations were boundaries have effect on the collaborative activities. Our hypothesis is that boundaries most likely manifest themselves as obstacles in the collaboration that hinder collaborators to precede as usual. Therefore, we have explored team activity situations in which tension or trouble in the collaboration was detected, as a potential source of boundaries operating. These situations were identified by explicit descriptions from participants

in interviews or questionnaires, by researcher observations in meetings or during teaching activities, or through analysis of the teaching activities documentation searching for failures of some kind. For this purpose, we have investigated the following data sources:

Participation and Observations. Both authors spent a substantial amount of time participating in the core activities of teaching model development in the project. The first author participated in many team activities within all four subjects adding to 589 h within the project, and she also spent two years' post-project analysis of the case. The second author was project leader in Sweden and coordinator of the subject mathematics and was involved in most activities related to that subject resulting in 1266 project hours. Researchers took part of all teaching activities in the project, either on-site in real time, via participation in video calls or via audio-visual recordings, or from written communication in e-mails, the project groupware, shared documents or Facebook groups. Examples of activities the authors participated in were 1) real-time participatory or off-line observations of recorded planning meetings, 2) non-participatory observations of virtual classroom teaching in-action (on-site in one local school), 3) on-site personal communication with involved teachers and students, and 4) participatory observations of reflection sessions with teachers and sometimes students. Such participation was crucial to detect the emerging teaching practice as well as trouble or tension in the collaborations sometimes leading to open conflicts.

Questionnaire First Year Experiences. Early in the project, a web-based questionnaire was distributed to teachers involved in the pilot group during the first year. The questionnaire covered the teachers' use experience of different digital technology prior to and within the project, and their views on technology usage for cross-boundary teaching so far in the project concerning sufficiency of available technology, resources for support, digital competence, time to learn technology, time to plan teaching, and time to conduct the teaching. The open-ended questions of experienced troubles or problems and their perceived support levels were used for this study. There were 16 teachers responding to the questionnaire after the first year. The respondents came from 9 different schools and 7 were Danish, 5 Norwegian and 4 Swedish.

Teaching Models Documentation – Indicating Realization Failure. The two authors have previously analysed 38 cross-boundary teaching models from 11 different teacher teams in detail, concerning the quality of the teaching model as plan and as realization in the classroom, reported in Pareto and Willermark (2018). As part of this study, 8 of these teaching models were revisited since in those the planned for teaching was not realized in the classroom, and therefore we explored if there were boundaries affecting the lack of realization. Since the detailed materials contain plans and descriptions as well as reflections on implementations, we were able to explore if boundaries played a role for the result.

Project Reports. Project evaluation reports written as reflections and summaries of the collaborative activities related to the five project themes (the four school subjects and IT-didactics). The reports were collecting experiences from all the teams reflecting the work in cross-groups and meetings within each theme, which were collected and summarized by the respective coordinator. Hence, the second author was responsible for the reports from mathematics, and both authors were actively engaged in national cross-theme meetings in which project report content was discussed. The reports addressed current topics of interest for all themes and groups selected by the project management, which included descriptions and researchers' reflections on project processes, team activities and development, problems and various kinds of solutions. This study included: a midway report (180 pages) dealing with barriers and potentials for Nordic cross-boundary teaching which had the characteristics of a formative evaluation; four final reports from each school subject (between 10 and 17 pages each) containing reflections on the team activities and processes from the respective subjects as well as findings regarding cross-boundary teaching and; a final IT-didactic report concerning technology experiences and use for cross-boundary teaching (18 pages) which discusses technology use in relation to teaching activities; reflects on challenges and opportunities and provides recommendations. The final reports contained summative evaluations and lessons learned.

Teacher Interviews. Six formal post-project interviews with participating teachers where conducted by the authors. The interviews focused on the teachers' expectations, challenges, and general reflections of their participation. They were recorded and transcribed. Beside this primary interview material, we have also used excerpts from interviews conducted by other researchers which were extracted from the different projects reports.

3.3. Data Analysis

During the first year it became apparent that the project was far more complex and difficult than anyone had expected, and therefore much time was spent on discussing difficulties and challenges among the participants in all project meetings. As a consequence, much attention was paid on problems and challenges needed to overcome, as well as possible gains and potentials with the cross-boundary collaboration to raise the motivation to continue. This became the overall theme in the midway report and the focus remained for the entire project duration.

To identify and analyse teachers' formation of an emergent work practice, we have studied the collaborating teams' activities and their progression over time. During this analysis, contradictions and tensions emerged as important and constantly recurring elements that characterized the collaboration. It appeared to cause frustration while also carrying learning potential. Therefore, we collected situations from all our data sources indicating tensions or contradictions in the cross-boundary collaboration, as manifested by frustration, clashes and sometimes conflicts between

collaborators or deviations from plans. Then, we tried to identify the cause of the tension or deviation, and grouped the material according to which type of boundary that was most likely causing the tensions. The boundary categories evolved from working with the empirical data, and were not determined in advance. Three types of boundaries emerged as prominent and therefore reasonable candidates for boundary categorization: *technological*, *organizational* and *cultural* boundaries. For example, technological difficulties arose when collaborating partners had incompatible technological equipment, organizational difficulties when they had incompatible regulations concerning time, technology use or curriculum demands, and cultural difficulties when they had incompatible ways of teaching practices or pedagogical values. Together with the troublesome situations, we explored how the participants handled the trouble. To make the collaboration work in these situations an effort to change was necessary, negotiated, and realized by the participating collaborators.

Reliability was assured through a reliability test (Bryman 2015) and the authors conducted the analysis by continuously discussing and harmonizing the proposed categories and the criteria to belong to a category. Some situations were judged to originate from more than one boundary and therefore belong to more than one category. The data sources were examined as follows: In the questionnaire the selected open-ended questions concerning experienced problems were all relevant to examine. The detailed descriptions of the 8 teaching models that failed to be implemented as planned, were explored with respect to boundaries as potential causes of the failures. The plan was compared with the outcome and the post-teaching reflections where used to identify plausible reasons for the difference and the team's suggested solution. If any boundary could be identified, its role was described. From the project reports conclusions, examples of challenges and troublesome situations, and reflections on development and learning regarding teaching practices were extracted and categorized. Moreover, relevant teacher interview quotations from the project reports were collected and combined with excerpts from the authors' own interview transcriptions. The fact that the authors spent a substantial amount of time participating in different team activities meant good prospects to achieve interpretive validity, i.e., that the researcher accurately portrays the meanings given by the participants to what is being studied (Maxwell 1992).

4. Results and Analysis

We will start by presenting simple numeric data of identified boundaries in the data sources in order to pursue a grasp of the extent of boundaries in the material. Then we proceed by explaining the boundary categories and provide examples of them respectively. In total, there were 121 situations identified involving at least one boundary. The distribution over the data sources are shown in Table 2 below:

Most of the descriptions of troublesome situations involving boundaries originate from the midway report, reflecting that the challenges of the collaboration were at its peak during this time. Also in the final report there were descriptions of cross-

Table 2. Identified boundaries and their distribution over data sources

Boundaries Data sources	Organizational	Organizational and Technological	Technological	Cultural	Total
Questionnaire	0	4	6	4	14
Midway report	7	11	25	11	54
Final reports	7	6	20	8	41
Teaching models	3	0	3	6	12
Total	17	21	54	29	121

boundary challenges, but more often together with ways of how these challenges were overcome and handled in various teams and situations. In the final reports there were 17 excerpts focusing on how boundaries was overcome and a new practice was formed, even though this was not an explicit topic of the reports. Of the studied 38 cross-boundary teaching models, 8 were labelled as not realized according to plan (see Table 3) and therefore interesting to examine further. In these descriptions we identified 12 boundaries in total, of these 6 were cultural, 3 were organizational and 3 were technological boundaries:

The analysis of the interviews did not focus on the number of obstacles, but instead focused on capturing teachers' in-depth narratives and gaining a more qualitative understanding of how obstacles played a role in the work, and is therefore not included in Table 2.

4.1. Boundary Categorization

Three categories of boundaries emerged during the analysis as frequently appearing in troublesome or conflicting situations. The clear division presented here were not as distinct in practice and several situations involve more than one boundary. For example, organizational and technological boundaries often overlap (see column 2 in Table 2). The presentation of the results reflects our attempt to clarify and structure the role of boundaries as mechanism for learning.

4.2. Technological Boundaries

Due to the project design of collaborating across geographic boundaries, technology became a necessity to bridge the geographic distance. That technology posed challenges at many levels are frequently addressed in all data sources, being the most common boundary. The midway report from IT-didactic states: "The sum of the technological challenges was much greater than expected [...] The analyse identifies technology as a huge challenge that must be solved in order for the project to develop". As evident from the 54 identified occurrences; technology mainly

Table 3. Overview of cross-boundary teaching models

Context				Teaching activity	Technology use											Activity analysis				
Subject	Teacher team	number	year	teaching sequence plan - content	video conference	digital chat	text message	shared documents	text production	sound production	image production	multimodal	sound distribution	image distribution	subject specific	Complexity level	realization failure: plan vs implement-ation	cultural boundary	organisational	technological
Mathematics	1	1	1	Enumerate 1-20	X		X				X					1	ok			
		2	1,5	School statistics			X								X	3	failed	X		
		3	2	Fraction problems				X							X	3	ok			
		4	2,5	Packaging factory				X								3	ok			
		5	3	Pizza feast				X							X	3	ok			
	2	6	1	Enumerate 1-30	X											1	ok			
		7	2	Explain fractions							X			X		3	failed	X	X	X
		8	2,5	Statistics - survey	X										X	3	failed		X	X
	3	9	1	Brain teasers	X											2	ok			
		10	1,5	Price comparison				X							X	3	ok			
		11	2	Math dictionary				X	X							3	ok			
		12	2,5	Product containers	X	X									X	4	ok			
		13	3	Base-10 system	X	X		X	X		X			X		4	ok			
	4	14	3	Educational game	X	X									X	4	ok			
Mother tongue	5	15	1	Presenting the School							X			X		2	ok			
		16	1,5	Newspaper articles			X		X			X				3	ok			
		17	2	Youth writers	X			X								3	ok			
		18	2,5	Poems	X			X								3	ok			
		19	3	Tell through a movie	X						X					3	failed	X		
	6	20	1	Everyday life in North			X	X			X					3	ok			
		21	1,5	Comics	X			X							X	3	ok			
		22	2	Poems	X			X		X			X			4	ok			
		23	2,5	Setting sketches	X			X	X	X		X	X		X	4	ok			
		24	3	Language differences	X	X	X									3	ok			
	7	25	2,5	Know your neigbour					X		X			X		3	failed	X		
		26	3	Character sketches					X		X			X		3	failed	X		
	8	27	1,5	Short story relay	X			X					X			3	ok			
Social sciences	9	28	1	Presenting the School							X	X		X		1	ok			
		29	1,5	Local Modern History	X					X	X	X				3	ok			
		30	2	Conditions in the	X	X	X	X			X	X				4	failed	X		X
		31	3	Gender	X	X		X	X		X			X		4	ok			
	10	32	2,5	Municipalities	X			X								2	ok			
		33	3	Political comersial				X			X			X		3	ok			
Science	11	34	1	Meteorology				X			X		X	X		1	ok			
		35	1,5	Water characteristics	X			X			X		X	X		3	ok			
		36	2	Environment & waste	X	X		X	X		X					4	failed		X	
		37	2,5	Organic chemistry	X	X		X			X		X	X		4	ok			
		38	3	Soil analysis	X	X		X			X		X			4	ok			

operated as a boundary related to issues of *availability, usability* and *competence*. Regarding availability, the access to technology both in terms of hardware and

software differed greatly between the collaborating schools. For example, teachers faced varying accessibility to mobile devices such as laptops and tablets and some had to settle for stationary equipment, which limited students' mobility and hindered students from finding a quiet place to do synchronous videoconferencing. Difficulties linked to availability are for example addressed in the midway IT-didactic report by the following quotes: "Computers are old and not working, computers are not up to date and can take up to 30 minutes just log in!" and "Of technical problems it should be mentioned that the schools lacked camera and video equipment" and "At the start of the project there was slow internet access, it got better gradually". Usability issues included insufficient network, inadequate audio and video streaming and incompatible tools. For example, technology recurrently failed to support the collaboration via videoconferencing including poor connection or lack of audio, as illustrated by: "It is not easy when three groups have to connect simultaneously by the iPads, suddenly a specific app is needed so we have to download it, and finally when we are able to log in, we could not hear what the Danes were saying*"* (teacher interview, mathematics') and "When we skyped, we could not get the audio to work on the Danish side. That's why the students chatted instead!" (teacher survey, mathematics), or "The technology was probably the worst; you could never hear Denmark but you could see they had a very good ppt [visual presentation] and they said we were good too" (field notes, student after a synchronous distance meeting). Furthermore, usability issues due to the usage of different tools among the collaborators caused realization failure in teaching model 8 and 30 and is also highlighted as illustrated by: "It is difficult to create *a* movie when students have used several different tools to make films" (teacher survey, social science). Additionally, technological competence constituted a difficulty within the project, where the lack or variety of digital competence brought difficulties in the collaboration. This is for example addressed as an issue in the IT-didactic midway report, as illustrated by: "The digital competence among teachers, school leaders and researchers varied a lot" and "How should participants acquire necessary digital skills and competencies?". Thus, technological boundaries frequently hampered the planning and realizing of cross-boundary teaching models and limited the possibility to realize didactic visions, as illustrated by the final project report from science:

> The pilot teaching model [the collaboration during the first year] in the science groups has mainly focused on getting technical solutions in place and making communication work, as well as finding software suitable for the work […] The academic aspect has been tuned down due to limited time as well as the need to get the technology in place.

However, the hindrance side of technological boundaries *also* involve an opportunity to learn and develop the teaching practice as disruptions due to breakdowns and contradictions also encourage and foster a problem-solving attitude and a more

flexible approach to teaching. For example, teachers developed their technological competence by taking on a more use-centred view on technology, i.e. from viewing technology as artefacts to means supporting pedagogical activities and become thereby more flexible in their choice of tools. In reflection sessions teachers described how they became more technologically competent during the project, e.g. how they familiarize with iMovie and Adobe Connect or held their first videoconference, how they tried out and learned new technologies and found new ways of teaching mediated by technology. Besides developing their technological competence, teachers also describe how they learned new approaches to technology: "I have become better at using digital tools and I do not underestimate the importance of testing it [technology] thoroughly and familiarizing myself with it [before conducting the teaching]" (teacher interview, mathematics). Teachers active engagement to tackle technological boundaries were also expressed in the final IT-didactic project report, as illustrated by: "In cases where synchronous collaboration created challenges, teachers were creative in their choices. They found substitutes for asynchronous collaboration opportunities, and some professional groups used wiki technology and blogs, among others".

The technological boundaries hence involve the learning mechanisms identification and coordination, as it creates situations in which these boundaries need to be reflected on and tackled during the collaboration (Akkerman and Bakker 2011). Moreover, the teachers developed a more flexible teaching practice including alternative plans in case of failure, as described the IT-didactic final report: "Teachers were usually not far from ideas, and were creative and found solutions to problems. In GNU [the project], most of the problems were converted to challenges, which were solved in one way or another". Since the project depended on technology usage, teachers were highly motivated yet somewhat frustrated midway through the project: "We have a vision and a desire to reach a goal, but then there are so many things getting in the way, such as technical devices and applications we are not allowed to use." (teacher interview, IT-didactic midway report). The final report from native language stress that the teachers learned how to avoid troublesome situations due to technology boundaries, as illustrated by: "Due to the fact that they have already tried to collaborate cross-border, and through previous attempts they have become aware of both academic and structural opportunities and challenges, the more 'experienced groups' have been able to avoid many pitfalls".

4.3. Organizational Boundaries

Since the cross-boundary collaboration stretched over different organizations, organizational boundaries became an issue. In the data sources we found difficulties rooted in organizational differences related to mainly *regulations and polices*, *logistics* problems and differences regarding *resources* such as time, competence or equipment. Differences with respect to regulations and polices became an issue early in the project. There were regulations regarding if student were allowed to bring

their own device; what software teachers were authorized to download and firewalls that blocked free software to be installed which limited teachers' freedom of action, as illustrated in the IT-didactic midway report: "There is a big difference in the extent to which students are allowed to bring and use their own computers, phones, etc. at school. For example, in some schools, students have their own iPads, while other schools only allow use of the school's devices", or by the IT-didactic final report: "In Norway, various IT policy decisions in the municipalities made the first [online] meetings difficult. In two of the municipalities, for example, there were restrictions hindering teachers to install software".

Logistics became a challenge in terms of coordinating schedules. In general, it was difficult to find common meeting times that worked for everyone involved, which resulted in initial time plans being postponed or that teachers tried to find other ways and channels to plan their meetings, as highlighted in the IT-didactic midway report: "Rather, teachers' greatest challenge within the collaboration has been to find common meeting times for online meetings, so they have used their own free time to communicate and collaborate on student activities. Here, there is a challenge in relation to logistical planning and the time allocated for online collaboration over the coming years", and "there have been no financial costs, but rather that the participants have spent a lot of their own time and not just working hours, in order to meet the project's requirements". Hence, assigned resources also constituted a challenge. The most prominent issue was time, including inequalities in terms of designated time to work in the project and overall lack of time, as the participation was more time-consuming than expected.

Another consequence of organizational boundaries was due to curricula differences. Disparities in the steering documents together with high demands to fulfil dense curricula meant that teachers started advocating their own agenda, to have the opportunity to act within the framework of their own organization. There were examples where national groups pre-planned the cross-boundary planning meetings in order to present a complete teaching model that they wanted to pursue, as illustrated by the following conversation between two local teachers in social science:

> Teacher X: Now we must convince him [cross-boundary colleague], that we should pursue this... Maybe we should assign him to choose a text at least? Or maybe it is better if we do that too… or does it feel like we override him then?
>
> Teacher Y: No, I think it will be good ... you know if you are stressed and have a lot to do and you receive a complete plan, it is something that makes it much, much easier for you. Am I right?

This led to frustration in the teams. Another teacher in native language described that she felt neglected in the planning and wrote the following post in a closed

Facebook group involving only national researchers and teachers: "Thank you for today! The discussions were of great value to me. Unfortunately, it feels like our [cross-boundary] colleagues decided everything in advance and that ideas and opinions are not discussed". Such pre-planning of meetings prevented open-ended discussions and was considered unacceptable so it seized to occur when the collaboration matured in the teams.

As illustrated, organizational boundaries challenge teachers' work in different ways. However, it also play a dialectic role in disrupting and challenging teachers' current views and practices of how to organize and implement teaching activities, as it was no longer possible to act or organize teaching as usual. Teachers became aware of their own organizational frames affecting their practice. They describe how they learned about differences and similarities of organizational factors between the school systems and the teaching profession in general as illustrated by: "[…] we got into general discussions that had added value for us ... For example, the situation with national tests and how it varied [across nations and schools][…] There were many such things that we compared and discussed "(teacher interview, mathematics). Thus, teachers became aware of overall professional conditions, organizational frames and habits regarding the practice and how these vary across organizations. This became evident through observations of teachers' work where they found new ways to navigate through various infrastructures. Such insights and actions are consistent with the learning mechanism identification, coordination and reflection (Akkerman and Bakker 2011). In time, teachers developed skills to become flexible and find new ways to communicate and workarounds. Due to disparate rules and regulations, teachers learned to navigate and find "a way" rather than "the way". They became constant problem-solvers coping with the challenging and unpredictable situation of cross-boundary teaching in situ. It became obvious in observations of the teachers' planning and implementation of teaching, where they came to have a plan B (and sometimes also a plan C) for alternative activities or approaches, if things did not go as planned.This is also reflected in teachers' ability to conduct cross-boundary teaching models, which was to a greater extent realized in accordance with the planning towards the end of the project, and reflect the learning mechanism of *transformation*, i.e., co-development of new practices.

4.4. Cultural Boundaries

The cultural boundaries refer to differences in views regarding *teaching practices and philosophies*, *different meeting cultures* and *linguistics*. Teachers describe how different teaching philosophies had to be negotiated between teachers from different countries as illustrated by: *"*We felt that we had a lot of great ideas, but found it difficult to gain support from the other teachers" (teacher interview, mathematics) or "We wanted different things... I think that it is both easier and more fun if the kids are involved in determining the content" (teacher interview, mathematics). The midway report from natural science, also stress cultural boundaries as a challenge, as

illustrated by: "Experiences from the project pinpoint different challenges, such as teachers in the project have different expectations and different frame of mind". These boundaries caused disruptions and contradictions when planning teaching, as. Illustrated by: "I think we have different cultural baggage. We have different curricula; different goals and I don't think that we declare this [to each other] … We just take it for granted" (teacher interview, social science). The linguistic dimension, being unusually apparent in this Nordic project, constituted a difficulty in terms of communication. However, it can be present without multi-lingual settings as well, due to cultural and local variations on communication practices and habits. Challenges' due to linguistic is apparent in the midway IT-didactic project report: "Difficulties in understanding each other when communicating in the respective Nordic language have been a constant struggle" as well as in the midway report in natrual science:" [T]here are clearly problems due to language differences. The virtual meetings have been hard, even if carried out with the combination of speech and writing". Often, teachers thought that they had a mutual understanding and agreement, but when they carried out planned actions misunderstandings were revealed. Miscommunication became evident when teaching plans were not realized in the same way among collaborators, as for example in teaching models 2 and 19 where only one part proceeded with the mutually decided task, or in teaching models 25 and 30 where different collaborators interpreted the task completely different. Also, in teacher reflections, disruptions caused by linguistic boundaries were apparent, as illustrated by: "On our skype meetings, sometimes I just zoomed out and shook my head… I couldn't understand*"* (teacher interview, mathematics) or "I think it's really, really hard to understand Swedish and Norwegian, although I can understand it in writing" (teacher interview in midway report, native language).

On the other hand, teachers also express how facing and bridging cultural boundaries led to learning and transformation of practice. For example, in cross-boundary meetings they constantly had to negotiate their teaching and therefore became aware of their own approach, as illustrated by: "One gets a new perspective on our own curriculum when you learn about their reasoning in the other countries: what is regarded as learning and knowledge? It has been very interesting" (teacher interview, social science). In order to cope with cultural differences teacher developed different strategies, i.e., they become explicit including ambitions, desires and hidden assumpions; where spoken and written language was routinely combined and important decisions always written and shared; and where concepts and deeper subject-related discussions and reflections were enabled. Due to speaking different languages, teachers came to modify their behaviour in time, becoming very clear and explicit in their communication, as revealed in teacher's communication observations. They elaborated on different strategies for planning, decision-making and implementation. For example, they developed a practice to combine written (chat) and spoken language during distance meetings and to always document in writing and share important decisions. Additionally, teachers described how they developed subject-specific competences when collaborating with their Nordic colleagues, as

illustrated by: "We gain a lot as we tested each other's different theories and thoughts" (teacher interview, mathematics). These perspectives also reflected in the final report from social science:

> This [diffenences] has led to teachers being able to have exciting subject didactic discussion about the understandings of the subjects and the differences between the countries. […] Teachers have had to look at their subjects in new ways […] and have constantly challenged their perspective.

Thus, the role of cultural boundaries challenged teachers' views in fundamental ways; it challenged their pedagogical ideas and beliefs about teaching and learning, their ways of planning and organizing teaching; and they reviewed and discussed key concepts within their subjects. Moreover, the language differences resulted in teachers beginning to reflect on subject-related concepts and their meanings. For example, when a team in the social sciences discussed the topic gender roles, a conceptual discussion arose around the term gender. In Swedish (as in English) the term is used as a gender-neutral description whereas in Danish the term translates to "female roles". This led to subject reflections and discussions, as illustrated by the following conversation between two Swedish teachers:

> Teacher X: We noticed that we had different prior understanding or attitudes, since many Danes used the term 'female roles' … several times… and after a while we responded: What do you mean by 'female roles'? It was interesting that they immediately assume that it is all about female roles…
>
> Teacher Y: And not 'gender roles'.
>
> Teacher X: Exactly. But I think we all agree now.

Hence, the cultural boundaries also played a role as obstacles as well as learning enablers. The learning mechanisms involved are identification, coordination and reflection as teacher own practice became visible in relation to "the other" (Akkerman and Bakker 2011). Furthermorer, to cope with the cultural differences, the collaboration meant that teachers had to engage with "the other's" point of view identified common frames to agree and act upon, i.e., correspond to the mechanisms of transformation, as finding concrete strategies to develop a cross-boundary practice (Akkerman and Bakker 2011).

5. Discussion

The above results show how boundaries became an important and ever-present ingredient in the teachers' collaborative work, and enabled the formation of a

cross-boundary teaching practice. Thus, at the end of the project teachers had adopted the new thinking and acting, and were more autonomous and realistic through the planning and implementation of the teaching in the virtual classroom. A boundary is defined as a "sociocultural difference leading to discontinuity in action or interaction" by Akkerman and Bakker (2011:133). Yet, the term "boundary" is often used relatively unfounded, in situations where discontinuities are expected rather than empirically detected, which is problematic if boundaries should serve as a meaningful analytic concept (Akkerman and Bakker 2011). In our study, the variation and extent of boundaries, beside some obvious differences based on nationality, were neither anticipated nor assumed in advance but became evident during the process. Instead, the identified boundaries were empirically informed results from teachers facing sociocultural differences, which affected the collaboration in direct and practical ways. In addition to identifying boundaries of technological, organisational and cultural nature, we identified themes for each category that described in more detail how the boundaries operated in practice and how teachers managed the boundaries over time.

5.1. Technology as Boundary Leverage

Due to the project set-up with distance collaboration in a virtual classroom technology use became inevitable, as it constitutes the premise for the project and the collaboration. This constituted a crucial aspect for enduring all disturbances created by technological boundaries. Further, the project required for teachers to experiment and reflect upon the role of technology in teaching in-depth, and continually find solutions to different technology-related challenges, brought new perspectives on, and approaches to, technology. As teachers expanded their technical repertoire and became more familiar with the affordances of different technologies, they started to do more informed, activity-based choices, regarding *what* and *how* technology could be used. Thus, the technological boundary posed a distinct challenge forcing teachers to re-think their previous assumptions and questioning established practice. However, this was not the only way that technology-related boundaries affected the project; instead technology functioned as leverage for the other boundaries as well. As for organizational boundaries, the different regulations that constrained what technical solutions that were sanctioned and possible to use within respective school caused further difficulties in the collaboration. However, it also served as a lever in stimulating a wider repertoire of tools to be used. In terms of cultural boundaries, technology functioned as leverage as the technology-mediated setting made it even harder for teachers to handle the linguistic differences. There is much evidence that technology-mediated collaboration entails increased complexity (e.g. O'Leary and Cummings 2007; Olson and Olson 2000), which in this case complicated an already challenging situation. On the counterpart, the situation also forced the reflection and development of clarity, by becoming very explicit in their communication. Regarding cultural boundaries, differences within the teams became more visible through

the explicitness regarding fundamental issues of the teaching practice and pedagagical views imposed by the technology-mediated collaboration. Without the technology-mediated setting, hidden assumptions and unconsious behaviours may never have reached the awareness surface and remained unreflected. Thus, technology had the dual role of operating as a separate boundary and as a leverage for the other boundaries, and therefore played an important role for reaching the level of transformation, and hence allowing learning and transformation of teaching practice to prosper.

5.2. Collaboration as Cross-Boundary Enabler

Teachers' participation in the project challenged their usual way of performing their practice in rather fundamental and direct ways and the cross-boundary collaboration played a crucial role for learning and transformation of practice to prosper. First, the cross-boundary collaboration functioned as a reflective mirror. As the collaboration comprising a need to constantly articulate their own pedagogical fundaments, ideas, values and ambitions to each other and causing teachers to (critically) reflect on their own perception. This relates to the identification and reflection mechanism, described by Akkerman and Bakker (2011). Second, the collaboration meant that teachers had to engage with "the other's" point of view and as a result they were continually confronted with perspectives, regulations, habits and actions that differed from their own, that needed to be handled and responded to in their direct work. It meant that teachers were not only continuously confronted with their taken-for-granted, established norms, attitudes and ideals; but also had to learn new ways of acting in this new setting. They had to discuss, negotiate and eventually form a common ground in order to pursue the project. This correspond to the mechanisms of coordination (i.e., forming cooperative exchanges between practices) and transformation (i.e., co-development of new practices) (Akkerman and Bakker 2011).

5.3. Managing Boundaries

Although this study shows how the composition of identified boundaries can serve as leverage for learning, it does not imply that boundaries per se promote such learning. After all, boundaries manifest themselves as disturbance, conflicts, clashes and frustration (Akkerman and Bakker 2011; Engeström 2001). In order not to be perceived as invincible, the boundaries must be accompanied with resources compensating for the challenges caused by the boundaries. This became evident during the project, which partly approached the limits of what was considered reasonable by the teachers, which shows how fragile learning can be. Thus, it is associated with risks to arrange challenging situations unless they are also balanced with reasonable conditions and support. In the project, time was identified as one such crucial condition. Knowing that the project would last over a long period of time was of importance since it generated commitment and active participation among the

involved parties, which was a prerequisite for learning while it took time to identify, confront and cope with boundaries. If the project has not strengthened over a longer period, it had probably been perceived as a setback by all participants, as illustrated by: "If the project had only lasted a year, it might have felt like a failure. It took a long time before we really felt that we owned the problem and could work confidently" (teacher interview, social science). Addtionally, flexible support was identified as crucial. In order for teachers to take on the challenging task, they requested activity-based support in their everyday work. The type of support required depended on the activity that was to be carried out. It included brainstorming ideas, receiving technical advice and support, and having an additional teaching resource in the classroom. In this case such support could be offered due to researchers' involvement. As teachers started to face difficulties they came to request increased research involvement. Knowing that the researchers were present on-site at school and in the classroom meant daring to try new things and practical experimentation. Teachers stressed the importance of close collaboration and getting support to overcome different boundaries, as illustrated by: "We [teachers and researchers] have been working very closely together, which has been very important" (teacher interview, mathematics) or "The conversations with you [researchers] have been of great, great value" (teacher interview, social science). In addition to the very practical and activity-based support, researchers also had an important role to encourage teachers and point out the progression in their work, which often passed unnoticed by the teachers. Instead, they often expressed self-criticism and tended to focus on what did not work as planned, due to for example technical problems or unexpected incidents. To show teachers progression in practice was important to keep motivation and energy during the project.

5.4. Limitations and Future Directions

As for the empirical results gained in this study, they are specific in many aspects. The longitudinal study takes place in, and is bound to, a Nordic elementary school context. A risk that is often highlighted in action research is that the studies are context dependent, which makes it difficult to generalize the results of individual studies (Baskerville and Wood-Harper 1998). However, in qualitative studies the central question is not whether the results are generalizable to a larger population, but how well they succeed in generating theory based on their results, referred to as "theoretical generalization" (Mitchell 1983) or "analytical generalization" (Yin 2009). Thus, the empirical results of this study should be understood as potentially generalizable to theory rather than population. Therefore, it is not statistical criteria but the explanatory power of theoretical reasoning that becomes relevant when assessing the results. We believe that the results from this study has broader theoretical implications than to explain this specific study, as it explicates the role of boundaries with respect to digitalization of work practices. We argue that such knowledge on how boundaries of different types can operate, interact and be

cultivated to stimulate learning could be transferred into other contexts where practices are to be changed. A future area of research will be to validate the results in other contexts.

5.5. Implications

We identified three principles for how boundaries can become valuable resources for learning with respect to digitalization of work practices:

Technology use can operate as boundary as well as leverage for other boundaries, in terms of increasing the level of challenge as well as the possible learning gain. If technology constitutes a necessity, it provides incentives to in-depth understanding and exploration of technology and its affordances, which pushes the limits of how much time and energy is considered reasonable to spend on learning, using and try out new technology to create learning situations.

Boundaries must be crossed in action, in order to "truly" challenge current views, beliefs and practices. It is not enough to be confronted with boundaries in terms of others' views and perspectives, which generally occur all the time in everyday life as well as through professional development initiatives such as courses or lectures. Differences must be negotiated and resolved in action, and with a common goal to achieve. Thus, transformation involves dialogue and collaboration between people representing different views and values, who at the same time have a mutually shared goal they want to fulfill.

Boundaries must be accompanied with sufficient resources. It is not enough to just "add" boundaries to a situation to promote learning. Instead, initiatives must be carefully crafted with resources to balance both sides of the boundaries, the challenges and the learning potential. Resources include time to reflect and transform which also means sufficient duration; there is no quick fix. Other types of resources may be required such as external support, competence, or discussion partners in order to overcome challenges and reach learning and transformation of work practices.

6. Conclusions

We have explored how boundaries operate to promote learning in a cross-boundary teaching setting. More specifically we have explored how the composition of boundaries of a technological, organizational and cultural nature operate and constitute a resource for learning. Even though boundaries often imply disturbances, conflicts and frustration, they simultaneously serve as catalysts for negotiations and innovation that may lead to learning and transformation of work practices. Hence, it is the dialectic role of boundaries being obstacles for retaining current practices in combination with the reflective and transformative power of overcoming these obstacles that is the key feature of boundaries for learning. However, boundaries per se are not enough for learning to occur, rather the contrary. The paper contributes with an explanation of how and why boundaries promote learning towards work practice digitalization, and principles for how to use boundaries for such purpose.

Acknowledgements

The Cross-Border Nordic Education project was funded by the European Regional Development Fund, Interregional IVA Öresund-Kattegat-Skagerrak. The authors would like to thank collaborating colleagues, teachers and students.

Funding Information

Open access funding provided by University West.

References

Akkerman, Sanne F; and Arthur Bakker (2011). Boundary crossing and boundary objects. *Review of Educational Research,* vol. 81*,* no. 2, pp. 132-169.

Bannon, Liam; and Sanne Bødker (1997). Constructing common information spaces. In *Proceedings of the Fifth European Conference on Computer Supported Cooperative Work. Lancaster, UK, 7–11 September 1997*. Dordrecht, The Netherlands: Springer, pp, 81–96.

Barrett, Michael and Eivor Oborn (2010). Boundary object use in cross-cultural software development teams. *Human Relations,*63, no. 8, pp. 1199-1221.

Baskerville, Richard; and Trevor Wood-Harper (1998). Diversity in information systems action research methods. *European Journal of Information Systems,* vol. 7, no. 2, pp. 90-107.

Billett, Stephen; and Sarojni Choy (2013). Learning through work: Emerging perspectives and new challenges. *Journal of Workplace Learning,* vol. 25, no. 4, pp. 264-276.

Bjørn, Pernille; and Lars Rune Christensen (2011). Relation work: Creating socio-technical connections in global engineering. In ECSCW 2011. Proceedings of the 12th European Conference on Computer Supported Cooperative Work, Aarhus Denmark, 24–28 September 2011. London: Springer, pp. 133–152.

Bradner, Erin; and Gloria Mark (2002). Why distance matters: effects on cooperation, persuasion and deception. In *CSCW 2002, Proceedings of the 2002 ACM conference on Computer Supported Cooperative Work, Louisiana, USA, 16-20 November*. New York: AMC Press, pp. 226–235.

Bratteteig, Tone; and Ingvild Eide (2017). Becoming a good homecare practitioner: integrating many kinds of work. In *Computer Supported Cooperative Work (CSCW),* vol. 26, no. 4, pp. 563-596.

Broberg, Ole; and Ingelise Hermund (2007). The OHS consultant as a facilitator of learning in workplace design processes: Four explorative case studies of current practice. *International Journal of Industrial Ergonomics,* vol. 37, no. 9-10, pp. 810-816.

Bryman, Alan (2015). *Social research methods*. Oxford University Press.

Carlile, P. R. (2004). Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries. *Organization science,* vol. 15, no 5, 555-568.

Constantinides, Panos (2012). Accountability in IT-Mediated Cross-Boundary Work: Insights from a Longitudinal Case Study. *Scandinavian Journal of Information Systems,* vol. 24, 1, 1-26.

Edwards, Richars; and Zoe Fowler (2007). Unsettling boundaries in making a space for research. *British Educational Research Journal,* vol. 33, no.1, pp.107-123.

Engeström, Yrjö (1995). Objects, contradictions and collaboration in medical cognition: an activity-theoretical perspective. *Artificial intelligence in medicine,* vol. 7, no. 5, pp. 395-412.

Engeström, Yrjö (2001). Expansive learning at work: Toward an activity theoretical reconceptualization. *Journal of Education and Work,* vol 14, no. 1, pp. 133-156.

Engeström, Yrjö; and Hannele Kerosuo (2007). From workplace learning to inter-organizational learning and back: the contribution of activity theory. *Journal of Workplace Learning,* vol. 19. no. 6, pp. 336-342.

Engeström, Yrjö; and Annalisa Sannino (2010). Studies of expansive learning: Foundations, findings and future challenges. *Educational Research Review,* vol. 5, no. 1, pp. 1-24.

Grönlund, Åke (2014). *Att förändra skolan med teknik: Bortom "en dator per elev"*. TMG Sthlm: Örebro universitet.

Bjerg Hall-Andersen, Lene Bjerg; and Ole Broberg (2014). Learning processes across knowledge domains. *Journal of Workplace Learning,* vol. 26, no. 2, pp. 91-108.

Harland, John; and Kay Kinder (1997). Teachers' continuing professional development: framing a model of outcomes. *British journal of in-service education,* vol. 23, no. 1, pp. 71-84.

Heracleous, Loizos (2004). Boundaries in the study of organization. *Human Relations,* vol. 57, no. 1, pp. 95-103.

Hermans, Hubert; and Agnieszka Hermans-Konopka (2010). *Dialogical self theory: Positioning and counter-positioning in a globalizing society*. Cambridge University Press.

Islind, Anna; Ulrika Lundh Snis; Tomas Lindroth; Johan Lundin; Katka Cerna, K; and Gunnar Steineck (2019). The virtual clinic: two-sided affordances in consultation practice. *Computer Supported Cooperative Work (CSCW)*, vol. 28, no. 3-4, pp. 435-468.

Johannessen, Liv Karen; and Gunnar Ellingsen (2009). Integration and generification—agile software development in the healthcare market. *Computer Supported Cooperative Work (CSCW),* vol. 18, no. 6, pp. 607-634.

Kinnula, Marianne; Netta Iivari; Minna Isomursu; and Sara Laari-Salmela (2018). 'Worksome but Rewarding'–Stakeholder Perceptions on Value in Collaborative Design Work. *Computer Supported Cooperative Work (CSCW),*vol. 27, no. 3-6, pp. 463-494.

Koehler, Matthew; and Puyna Mishra Mishra (2013). What Is Technological Pedagogical Content Knowledge (TPACK)? *Journal of Education,* vol. 193, no. 3, pp. 13-19.

Koh, Joyce Hwee Ling, Ching Sing Chai, and Wei Ying Lim (2017). Teacher professional development for TPACK-21CL: Effects on teacher ICT integration and student outcomes. *Journal of Educational Computing Research,* vol. 55, no. 2, 172-196.

Lamont, Michèle and Virág Molnár (2002). The study of boundaries in the social sciences. *Annual Review of Sociology,* vol. 28, no. 1, pp. 167-195.

Larsen-Ledet, Ida; and Henrik Korsgaard (2019). Territorial Functioning in Collaborative Writing. *Computer Supported Cooperative Work (CSCW),* vol. 28, no. 3-4, pp. 391-433.

Lewkowicz, Myriam; and Romain Liron (2019). The Missing "Turn to Practice" in the Digital Transformation of Industry. *Computer Supported Cooperative Work (CSCW),* vol. 28, no. 3-4, pp. 655-683.

Maxwell, Joseph (1992). Understanding and validity in qualitative research. *Harvard Educational Review,* vol. 62, 3, pp. 279-301.

Miles, Matthew; and Michael Huberman, A. M. (1994). Qualitative data analysis: A sourcebook. Beverly Hills: *Sage Publications*.

Mitchell, J, Clyde (1983). Case and situation analysis. *The Sociological Review,* vol. 31, no. 2, pp. 187-211.

Nardi, Bonnie, A; Steve Whittaker; and Heinrich Schwarz (2002). NetWORKers and their activity in intensional networks. *Computer Supported Cooperative Work (CSCW),* vol. 11, no. 1–2, pp. 205–242.

Nilsson, M., & Hertzum, M. (2005). Negotiated rhythms of mobile work: time, place, and work schedules. In Proceedings of the 2005 international ACM SIGGROUP, Conference on Supporting group work, Florida, United States, 6–9 November. Association for Computing Machinery.

O'Leary, Michael Boyer; and Jonathon N. Cummings (2007). The spatial, temporal, and configurational characteristics of geographic dispersion in teams. *MIS Quarterly*, vol. 31, no. 3, pp. 433-452.

Olson, Gary M; and Judith S Olson (2000). Distance matters. *Human-Computer Interaction,* vol. 15, no. 2, pp. 139-178.

Pareto, Lena; and Sara Willermark (2018). TPACK In Situ: A Design-Based Approach Supporting Professional Development in Practice. *Journal of Educational Computing Research*, vol. 57, no. 5, 1186-1226.

Randell, Rebecca; Stephanie Wilson; and Peter Woodward (2011). Variations and commonalities in processes of collaboration: the need for multi-site workplace studies. *Computer Supported Cooperative Work (CSCW),* vol. 20, no. 1-2, pp. 37-59.

Stake, Robert, E. (1995). *The art of case study research*. London, Sage Publications.

Timperley, Helen (2007). *Teacher professional learning and development: Best evidence synthesis iteration*. Wellington, N.Z.: Ministry of Education.

Vetenskapsrådet. (2002). *Forskningsetiska principer inom humanistisksamhällsvetenskaplig forskning*. Stockholm:Vetenskapsrådet. http://www.gu.se/digitalAssets/1268/1268494_forskningsetiska_principer_2002.pdf

Walsham, Geoff (1995). Interpretive case studies in IS research: nature and method. *European Journal of Information Systems,* vol. 4, no. 2, pp. 74-81.

Weise, Sebastian, Paul Coulton, and Mike Chiasson (2017). Designing in between local government and the public–Using institutional analysis in interventions on civic infrastructures. *Computer Supported Cooperative Work (CSCW),* 26, 4-6, no. 927-958.

Willermark, Sara; and Lena Pareto (2015). *Progression in Practice: Development of TPACK in didactical designs.* Paper presented at the *Society for Information Technology and Teacher Education International Conference, Las Vegas, USA, 29 March – 2 April 2015*, Association for the Advancement of Computing in Education.

Willermark, Sara; Lena Pareto; and Sylvana Sofkova Hashemi (2016). Didactical Design in use - Exploring Technological, Pedagogical and Content Knowledge. *In Proceedings of the 5th International Conference on Designs for Learning, 17-20 May,* Aalborg Universitetsforlag.

Yin, Robert. K. (2009). *Case study research design and methods*. Thousand Oaks, CA: Sage Publications.

Yin Robert K. (2017). *Case study research and applications: Design and methods*. Thousand Oaks, CA: Sage Publications.