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Davidson, Jacob; Vanderlinde, Ruben

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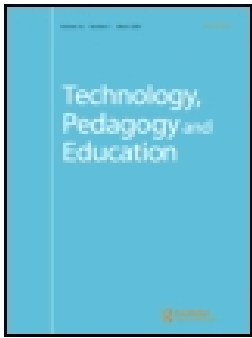
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‘You should collaborate, children’: a study of teachers’ design and facilitation of children’s collaboration around touchscreens

Jacob Davidsen^{a*}  and Ruben Vanderlinde^{b,c}

^a*eLearning Lab, Aalborg University, Aalborg, Denmark;* ^b*Department of Educational Studies, Ghent University, Ghent, Belgium;* ^c*FWO Flanders (Flemish Fund for Scientific Research), Brussels, Belgium*

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Touchscreens are being integrated into classrooms to support collaborative learning, yet little empirical evidence has been presented regarding how children collaborate using touchscreens in classrooms. In particular, minimal research has been directed towards how teachers can design for and guide children’s touchscreen-based collaboration. Concurrently, the Programme for International Student Assessment and other international organisations have highlighted collaboration and ICT skills as crucial competencies for mastery in the twenty-first century. Accordingly, this article presents three narrative cases from a touchscreen project in Denmark, where 41 second-grade children and three teachers from two classrooms participated. The cases are based on ethnographic field data and 150 hours of video footage of natural occurring interaction in classroom settings. The ethnographic field data and video footage are examined using a collaboration model and embodied interaction analysis. Each case presents features of the subtle processes of children’s collaboration around touchscreens and teachers’ role in designing and guiding such collaboration. Thus, this article illustrates teachers’ and children’s situated processes of integrating touchscreens for collaborative activities in their classrooms.

Keywords: children’s collaborative learning; instruction; video analysis; narrative research; twenty-first century skills

Introduction

For more than three decades, researchers and practitioners have been investigating how computers can best help children learn to collaborate. The concept of collaboration and the use of information and communications technology (ICT) in education have been particularly emphasised in recent policy papers and research reports (Luckin et al., 2012) on so-called twenty-first century skills (Dede, 2010; Voogt & Roblin, 2012). Additionally, the technological development of shareable, mobile, interactive and networked devices (e.g. interactive whiteboards [IWBs], smartphones, tablets, tabletops and touchscreens) has highlighted the relevance and urgency of focusing on how such technologies can help children learn to collaborate. Responding to this development, the Programme for International Student Assessment will begin testing children’s collaborative problem-solving skills on an international level in 2015 (Organisation for Economic Co-operation and

*Corresponding author. Email: jdavidsen@hum.aau.dk

Development, 2013). Such testing suggests a worldwide consensus on the importance of collaboration as a fundamental skill to learn in the twenty-first century. At the same time, it highlights the timeliness and relevance of the current article to policy makers and teachers.

This article focuses exclusively on face-to-face collaborative learning supported by the use of touchscreens in primary school classrooms – a format that is receiving increasing attention from researchers (Higgins, Mercier, Burd, & Hatch, 2011) and practitioners. For instance, Rick, Marshall, and Yuill (2011) observed a high level of awareness between children working in pairs with DigiTile (a software application that enables participants to collaboratively construct patchwork quilts and pattern tiles) on a tabletop. However, the children were working in parallel sessions on the shared surface; that is, they worked on individual projects instead of solving problems together. Higgins, Mercier, Burd, and Hatch (2011) and Higgins, Mercier, Burd, and Joyce-Gibbons (2011) conducted a study on the SynergyNet project, an initiative that investigated the process of integrating multi-touch tabletops into teaching and learning activities. The authors found that children tend to more positively collaborate in activities based on multi-touch tabletops than in paper-based tasks. Despite the growing literature on technology-based collaboration, research is lacking on how teachers should design for and guide children's collaboration, with support from touch-enabled devices (e.g. incorporating collaboration into pedagogical practice). To address this gap, the current study presents three narrative cases that show (a) how children engage/disengage in collaborative activities around touchscreens and (b) how teachers can design for and facilitate children's touchscreen-based collaborative activities. By presenting and discussing three narrative cases at the nano curriculum level (van den Akker, Kuiper, & Hameyer, 2003) – the level of the individual learner – we show, analyse and discuss how children collaborate and what role teachers play in facilitating this process. The narrative cases are based on ethnographic field data and more than 150 hours of video footage collected in two Danish classrooms over one school year.

ICT and the role of the teacher

At a policy level, several attempts have been made to identify and describe the competencies that children need for the future and the ways through which teachers should teach to enable children to master such competencies (Vanderlinde, van Braak, & Hermans, 2009). These competencies are often referred to as twenty-first century skills, for which several frameworks have been proposed at an international level and in Denmark. Descriptions of twenty-first century skills generally relate to all major dimensions of a person's life, such as citizenship, self-realisation and work (Dede, 2010). More specifically, these skills fall under five broad key competencies:

- intellectual and thinking skills;
- innovation and learning skills;
- communication and collaboration skills;
- life and citizenship skills; and
- ICT skills.

Dede (2010) stated that because of the emergence of highly sophisticated ICTs and their effects on the ways by which we learn, work and communicate, ICT skills

are highly integrated with the four other skill categories. An essential requirement, therefore, is for schools to consider modifying educational goals and devising approaches to integrating new tools into pedagogical practice.

Despite the current emphasis on the importance of developing ICT and collaboration skills in the twenty-first century, a gap separates the abstract descriptions found in macro-level policy frameworks (van den Akker et al., 2003) and the nano-level operationalisation of these descriptions (van den Akker et al., 2003). For example, an updated guide to ICT and media competencies in Danish primary schools (Undervisningsministeriet, 2010) exclusively addresses children's learning outcomes whilst disregarding teachers' competencies in facilitating learning processes. The guide neglects the fact that teachers are crucial agents of change in the concrete integration of ICT in the classroom, which has been confirmed by the research results of nano-level technology integration projects (Albirini, 2006; Davidsen & Georgsen, 2010; Davidsen & Vanderlinde, 2014a). Beauchamp and Kennewell (2010, p. 760) supported this line of reasoning, indicating that 'only when ICT was sufficiently embedded in teachers' pedagogical knowledge did the technology contribute positively to learning'. Likewise, Ottestad (2010, p. 478) argued that 'teachers play a crucial role in redeveloping schools into modern, technology-enhanced institutions'. This discussion relates to the general delineation of teachers' roles into two central positions: (a) teachers as executors of a given curriculum for a system and (b) teachers as designers of a curriculum, with their knowledge of methods, tools and children used as a basis in design (Westbury, 1998). Overall, studies have demonstrated the importance of augmenting teachers' ICT pedagogical skills at the nano level to promote and support their teaching and facilitation of children's ICT-supported learning. In other words, researchers should aid and support teachers' translation of twenty-first century skills at the macro level, which needs to be contextualised and situated in teachers' own practice at the nano curriculum level for a successful integration.

Interactive technologies in classrooms

Despite the fact that many countries have infused massive investments into ICT for primary education over the past few decades, several unresolved issues remain (Selwyn, 2011). For example, few studies have been conducted on the ways in which shareable and interactive technologies support children's collaborative learning in classrooms (Higgins, Mercier, Burd, & Hatch, 2011). Meanwhile, researchers have extensively studied the benefits of integrating IWBs into classroom teaching. In this regard, research can provide important pedagogical insights into the integration of touchscreens and tabletops into classrooms. For instance, researchers have proposed several frameworks that can serve as scaffolds for discussions on integrating IWBs into classrooms. Beauchamp and Kennewell (2010) developed a framework for understanding and cultivating interactivity in technology-rich classrooms. Their interactivity framework includes the following interaction categories: no interaction, authoritative, dialectic, dialogic and synergistic. The framework also differentiates between interaction with and without ICT. Mercer, Hennessy, and Warwick (2010) also stated that IWBs can change interaction and participation patterns in classrooms. Mercer et al. based their analysis on Alexander's (2008) concept of a dialogue-inspired teaching approach that characterises dialogue in teaching as collective, reciprocal, supportive, cumulative and purposeful. On the basis of classroom

observations, Mercer et al. suggested that IWBs and a dialogue-inspired teaching approach can establish a space for the co-construction of knowledge and meaning making between teachers and pupils (Mercer et al., 2010; Twiner, Coffin, Littleton, & Whitelock, 2010). Both these frameworks provide guidelines for facilitating and designing whole-class interaction, group interaction and individual interaction with ICT. Nevertheless, prioritising and strongly emphasising verbal interaction in these frameworks disregard the importance of the body and the material world in human interaction, collaboration and learning.

Another interactive technology that is gradually being integrated into classrooms is interactive multi-touch tabletops. Despite such progress, however, Higgins, Mercier, Burd, and Hatch (2011) identified a lack of research on the facilitation of children's collaboration supported by interactive touch technologies. The majority of research has been directed only towards pupils' interaction around one tabletop in a laboratory setting (Kharrufa, Martinez-Maldonado, Kay, & Olivier, 2013). For example, Higgins, Mercier, Burd, and Joyce-Gibbons (2011) offered their perspectives on touch-mediated interaction, but their work was based solely on coding and counting verbal interaction amongst the children using a tabletop. Harris et al. (2009) reported the amount of talk and number of screen touches during children's group activity around a multi-touch table. The authors concluded that children's participation is more task oriented on multi-touch tables, and turn-taking is more widespread with single-touch based technology. Addressing the design and implementation of touch technology for teaching, Dillenbourg and Evans (2011) proposed 33 points for consideration when integrating interactive tabletops into educational settings. These points include practical and pedagogical factors. As pointed out by Davidsen and Christiansen (2013), however, researchers and practitioners remain uncertain as to whether the results of these and other experimental and design studies are applicable in everyday classroom settings and whether they can inform a pedagogical perspective on the facilitation of collaboration supported by interactive touchscreens.

Overall, the IWB studies discussed here were conducted in classroom settings but were primarily directed towards orchestration, with a central teacher position emphasising verbal interaction. Existing studies on tabletop-supported collaboration have primarily been carried out in experimental laboratory settings and have only reported the amount and type of talk and the number of times each participant touches a tabletop. IWBs and tabletops augment physical movement and manual input, yet research has primarily dealt with the orchestration and facilitation of verbal interaction amongst children and equality concerning individual participation. We argue that a theoretical perspective informed by Murphy's (2004) collaboration model and embodied interaction analysis (Streeck, Goodwin, & LeBaron, 2011) extends the scope of the literature by demonstrating how children engage/disengage in collaboration and how teachers can design for and facilitate collaboration supported by touchscreens.

Theoretical perspectives on collaboration

Collaboration is a central skill in many frameworks that describe twenty-first century skills, but it is a difficult pedagogical concept for teachers to operationalise in classroom practice because decoding what collaboration refers to and how teachers should engage children in collaborative activities is difficult to accomplish (Luckin et al., 2012). For the purpose of this article and to frame a discussion about the

concept of collaboration found in frameworks that describe twenty-first century skills at the macro level (van den Akker et al., 2003), we introduce and combine Murphy's (2004) collaboration model and embodied interaction analysis (Streeck et al., 2011).

We contend that Murphy's (2004) collaboration model can function as a tool for teachers' reflection on their actions and future learning designs. Although Murphy intended for the model to be used in analysing asynchronous online discussion forums, the stages of collaboration that it identifies are highly relevant to understanding and analysing children's collaborative activities around touchscreens. The model's theoretical and empirical foundations draw on a compilation and comparison of findings concerning collaborative activities in face-to-face settings. For example, the model is grounded on Roschelle and Teasley's (1995, p. 70) definition of collaboration as a 'coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem'. Compared with Beauchamp and Kennewell's (2010) model of interactivity and Alexander's (2008) concept of dialogue-inspired teaching, the collaboration model emphasises the establishment of intersubjectivity amongst peers and the shared production of artefacts, rather than how teachers can facilitate verbal interaction in the classroom. The model consists of six stages of collaboration (Figure 1).

The model also indicates that, to reach higher stages of collaboration, peers must first establish social presence (e.g. get to know each other and tune in on an activity) because such behaviour creates group cohesion, which can enrich collaboration amongst peers. At the next stage, peers present their individual perspectives on the present task, and these perspectives may resemble individual monologues. The third, fourth and fifth stages relate to Suthers' (2006) definition of collaboration as a process of intersubjective meaning making. Peers define and refine a shared goal, motive or intention, and the teachers' designed tasks are transformed into activities (Goodyear, 2005). At the final stage of collaboration, interaction leads to the production of shared artefacts. Stahl, Ludvigsen, Law, and Cress (2014) noted that artefacts are crucial for collaborative learning because they function as materials for negotiation, interaction, interpretation and re-configuration. In the collaboration model, the first stages are prerequisites to the final stage of collaboration.

Murphy's (2004) collaboration model differs from the focus of embodied interaction analysis (Streeck et al., 2011) in that the latter suggests viewing human interaction as a complex of language and body movement in the material world. We argue that collaboration supported by touchscreens and other interactive technologies in classroom environments should also be framed within the theoretical perspectives of embodied interaction. This approach is a holistic endeavour in which language, body movement and the material world create and carry interactional meaning in specific situations or practices (Streeck et al., 2011). Klerfelt (2007) stated that studying gestures and body movements when computers are used as mediational means in children's learning activities is particularly interesting because gestures and body movements uncover the unspoken interaction amongst children. In the context of the current project, the children's gestures functioned not only as metaphoric, symbolic or deictic acts (e.g. pointing at the screen, means of communication), but also as direct or 'pragmatic' input in the children's shared workspaces (Streeck, 2013). In other words, embodied interaction analysis considers how participants engage in meaning making and express understanding through language, body movement and material objects.

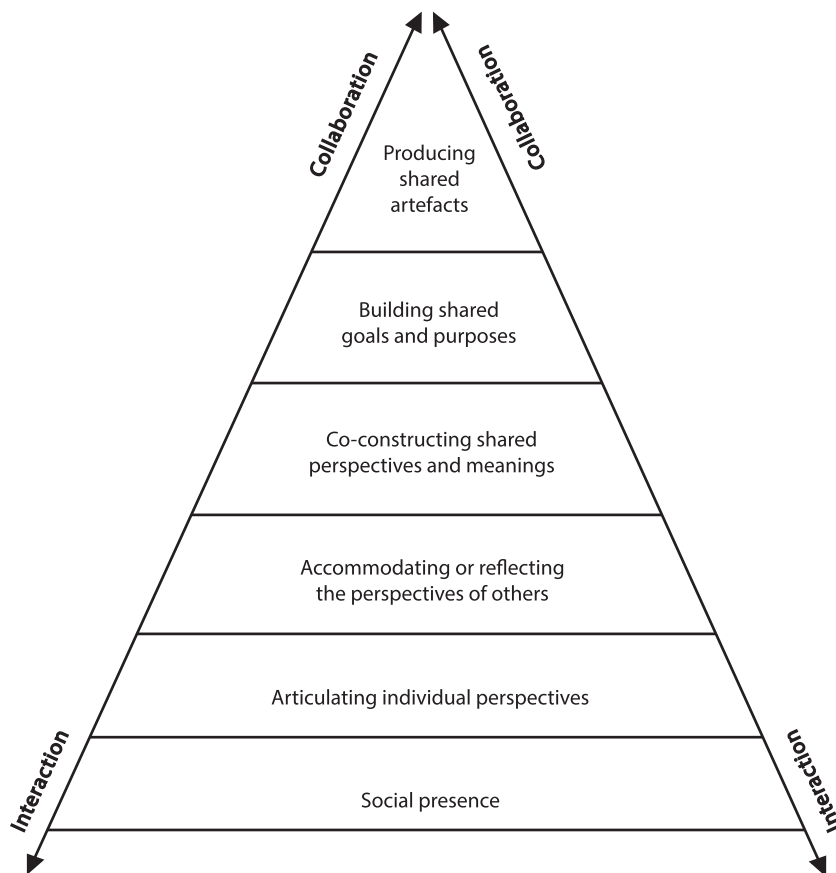


Figure 1. Murphy's (2004) collaboration model.

Streeck (2008) and Streeck et al. (2011) extensively illustrated how humans use language, body movement and materials to make sense of one another's contributions and construct shared understandings in a variety of settings. Rather than viewing language, body movement and materials as individual interactional resources, this theory argues that these resources create a multimodal fabric of meaning, action and interaction (Streeck, 2008). This concept underlines the importance of interweaving the different interactional resources into a whole, both theoretically and analytically. We suggest that this perspective can extend and inform Murphy's (2004) collaboration model. In combination, they enable an understanding of children's collaboration around touchscreens and serve as a tool for the design and facilitation of collaboration in the classroom. These theoretical perspectives inform and function as tools for the narrative cases presented later. In addition, we use these theoretical perspectives to situate our findings within the work of related studies.

Context of the study

The findings are presented in the context of a long-term technology integration project called 'Move and Learn' at Western State School¹ (WSS) in Denmark. A

research team (of which one member is the first author of this article) followed the project throughout a year and collected rich data. Three teachers and 41 children at year 2 (ages 8 and 9) participated in the project. For the purpose of the initiative, two IWBs and sixteen 23-inch touchscreens installed with Smart Notebook™ software were placed in two separate classrooms. As part of the technological infrastructure, every unit was connected to the Internet (without any filter), and each child was given a headset and a USB pen drive. The teachers and children worked within the same interface with similar tools. Hence, the children had exactly the same workspace as that found on the IWBs, only on a smaller screen when they paired up to use the touchscreens. The goal of Move and Learn was to promote children's desire to learn, desire to learn with others and desire to learn in different ways through touchscreens. Thus, the aim of the project was to explore, in natural classroom settings, the benefits of integrating touchscreens into teaching and learning.

During the project, several pedagogical issues emerged for both teachers and children. The teachers were confronted with pedagogical issues of designing for children's collaboration and identifying an appropriate way to facilitate collaborative processes around the touchscreens. Example issues are which designs will foster collaborative interactions amongst the children and how collaborative activities can be guided and facilitated. Likewise, the children were compelled to develop methods for engaging/disengaging in collaborative activities. For instance, they had to find methods for dealing with social, technical and academic issues. The teachers were developing ways of integrating the touchscreens into both learning processes (how children learn) and subject-specific content (what they learn). They therefore explored the affordances of this setup in their practice (e.g. what tasks promote collaboration amongst the children). The teachers did not base their exploration on any theoretical or methodological position suggested by the researchers, but the teachers and researchers met for video feedback sessions. During these sessions, the researchers provided video clips for collaborative viewing and analysis. The teachers and researchers viewed situations from the classrooms together, thereby learning together and from one another (Davidsen & Vanderlinde, 2014b). In many ways, these sessions shaped the professional vision (Goodwin, 2000) of both the teachers and researchers; that is, it revealed how the children engage/disengage in collaboration around touchscreens.

The physical arrangement of the technology-rich classrooms at WSS created an environment that differs from most whole-class teaching settings. Instead of sitting in rows facing the teacher, the children (denoted as small circles in Figure 2) were positioned next to the classroom walls. Organising the children's workplaces into small islands and placing the teacher's desk in a corner created room for movement and immersion.

When giving instructions, the teachers either stood next to the IWB or moved around it. Whilst being instructed, the children sat on chairs next to each other or on the floor in front of the IWB (only when they worked together on collaborative tasks did the children use the touchscreens). In other words, shifting from a mode of instruction to a mode of learning in this setting was a visible act given that the children moved from their individual chairs to team up in pairs in front of the touchscreens and work with the learning materials developed by the teachers. In this mode, the children rarely discontinued their collaborative learning activities even as the researchers or other teachers walked in and out of the classrooms. However, the

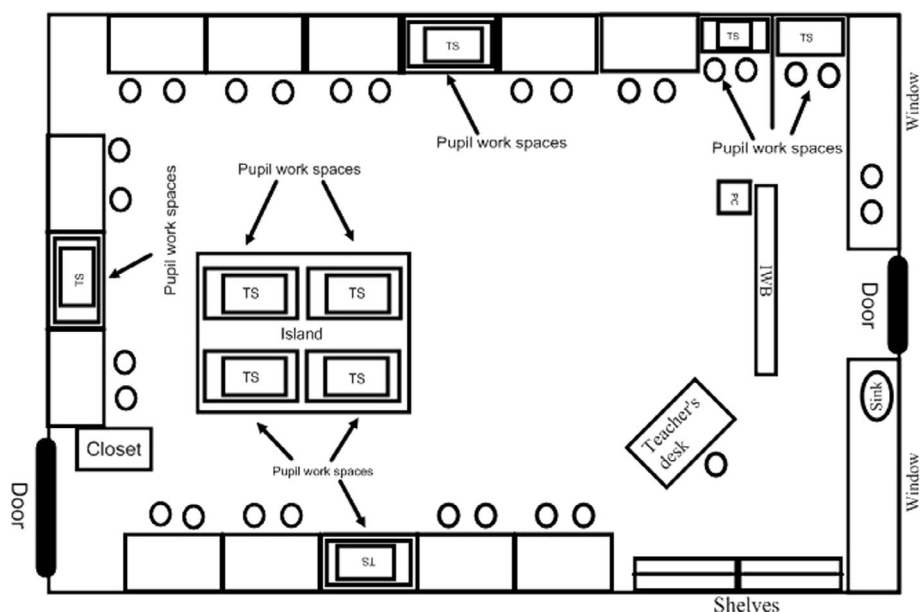


Figure 2. Classroom arrangement.

children often performed ‘off-task’ activities (e.g. establishing social presence) whilst working together (Murphy, 2004).

Over one year, the research team studied the activities in the classrooms, with particular focus on the manner by which the children engaged/disengaged in collaboration and the method by which the teachers approached the design and facilitation of collaboration. This focus was therefore the general research objective of the project.

Method

This research project’s overall methodological approach can be categorised as descriptive (Stahl, Koschmann, & Suthers, 2006) because it was intended to uncover and elucidate how embodied meaning making unfolds in practice. The research team also sought to establish a mutual learning partnership with the teachers and did not directly impose a research agenda or design on the teachers. The research process was divided into two steps: data collection and data analysis, which were intertwined during the project (as demonstrated, for example, by the video feedback sessions). This article presents the outcomes of the research process as three narrative cases based on the data collection and applied theoretical perspectives.

Data collection

We collected ethnographic field data, such as interviews with the children, teachers and parents; classroom event logs; on-site observations; participating teachers’ blog reflections; and photographs. In addition, the researchers – with support from the teachers – recorded more than 150 hours of video data in the two classrooms.

Because the researchers could not be present at the school every day, the teachers managed most of the recording (e.g. switching the cameras on and off). In each of the classrooms, three cameras were positioned above the touchscreens to capture how the children interacted with one another and with the touchscreens. Given the number of cameras, we could follow different pairs' interpretations of the teachers' tasks and the children's methods of engaging/disengaging. This also enabled a comparison of how the children acted and responded to different tasks. The video recordings captured the interactions amongst the children and provided valuable insights into classroom management, the children's interactional patterns and the influence of the teachers and other children on the work and actions of each child. As discussed by Davidsen and Christiansen (2014, p. 34), children use language, the body and materials to 'constrain and control access, to construct and problem solve, and to show and imitate'.

Data analysis

Embodied interaction analysis (Streeck et al., 2011) was the primary methodological foundation for analysing the interaction playing out in the classrooms. This approach draws on ethnomethodology (Heritage, 1984) and interaction analysis (Goodwin, 2000) and aims to uncover how actors make sense of one another's actions in practice through language, body movement and material surroundings. This type of analysis focuses on 'what happens next' in a situation to interpret actors' understanding of the situation, instead of labelling their actions by using predefined analytical categories (Heritage, 1984). In addition, ethnomethodology suggests that every situation which participants treat as collaborative should be taken as an example of exactly that phenomenon (Koschmann, Stahl, & Zemel, 2007). Thus, we have selected three examples showing how teachers design for and guide children's collaboration around touchscreens in order to show exactly that phenomenon. The three cases were selected from a larger collection of clips that show teachers guiding pairs in the classrooms. Using Transana (Woods & Fassnacht, 2015) – a tool for video analysis –, we produced a preliminary collection of 248 situations in which teachers were guiding children in addressing technical, social or collaborative issues. Based on this collection, we present three narrative cases showing and exemplifying the teachers' facilitation of the children's collaborative processes. Each of the selected examples illustrates some of the subtle ways teachers design for and guide children's collaborative processes; moreover, the three cases show differences in the children's embodied methods for engaging/disengaging in collaboration.

In order to make visible some of the ways the teachers designed for and guided the children's collaboration, we translated the collected data into three 'digestible' narrative cases (Derry et al., 2010, p. 12), thereby representing action, dialogue and context in an understandable and authentic fashion. Narratives, including fictional and non-fictional stories (Wyatt, 2007), have become increasingly popular in the humanities and the social sciences as tools for inquiry into practices and representations of practices to other researchers and practitioners (Clough, 2002; Czarniawska, 2004). For example, de Freitas (2004) used narrative fiction to describe the tensions between personal life history and the canonical mathematics curriculum, as experienced by a novice mathematics teacher. The author argued that narratives can serve as pedagogical and reflective tools, as in the case wherein a teacher's experiences in a similar situation are illustrated to other new teachers. Accordingly, we translated

the detailed transcripts into three narrative cases to make the complex embodied interaction understandable and enable readers to feel as though they were present at each situation. This narrative representation of the video data provides a way of visualising and illuminating how the children engaged in collaborative activities around the touchscreens and how the teachers designed for and facilitated their collaboration. In addition to the written narratives, small strips of multimodal transcripts (Figures 4, 6 and 8) were produced to show how the children engaged/disengaged in meaning-making processes through language, body movement and materials guided by the teacher.

Three narrative cases from the touchscreen environment

This section presents three narrative cases that describe the children's collaborative embodied interactions at the nano curriculum level (van den Akker et al., 2003). These cases outline how three different pairs of children collaborated using the touchscreens. For each narrative, we first introduce some of the general characteristics of the children's collaboration patterns and then interpret the situations by applying Murphy's (2004) collaboration model and knowledge from embodied interaction analysis studies. Finally, we discuss what the three narratives suggest about children's touchscreen-supported collaboration and, most important, relate it to how teachers can design for and guide children's collaboration around touchscreens in classrooms.

Narrative case one: 'Collaborate now, children'

The children and teachers had been working in the technology-rich learning environment for one month, and novelty was diminishing. Focus on collaboration, on the other hand, was increasing. However, the concept of collaboration was unclear to both the children and teachers. Most of the learning materials had been copied from textbooks – digital versions of existing materials. Moreover, the children and teachers had not discussed how to collaborate and what it actually means to collaborate. In other words, the children were told to collaborate without any clear-cut 'script' to follow; for example, they were compelled to develop, negotiate and discuss 'what it means to collaborate' whilst doing it.

Peter and Julie were sitting together in front of a touchscreen, composing sentences by drawing lines between words on the screen. Julie was in control of the screen for most of the activity and pushed Peter away, both verbally and physically. They were not even taking turns in creating sentences. A few times, Julie invited Peter to contribute but instantly changed her mind and continued her work. At one point, Julie decided to erase their work without consulting with Peter. Peter was becoming increasingly frustrated over being denied the opportunity to contribute his solutions to the shared workspace. Julie continued to hold Peter back with her hands, and she removed his fingers from the screen several times. Whenever Peter's attention veered from Julie's work, however, she involved him in the task. Essentially, therefore, Peter was positioned as a spectator by Julie and not as a capable peer.

Peter's actions were getting attention from the teacher, and the teacher, from a distance, said, 'Are you concentrating about this, Peter?' Peter responded by saying that Julie would not let him contribute. Once again, from a distance, the teacher

Interpretation

As this narrative case illustrates, furthermore, the teacher's intervention did not significantly change the interaction and collaboration pattern. The situation gave rise to an opportunity for the teacher to engage in a discussion about collaboration with the pair – a learnable moment (Majlesi & Broth, 2012), yet the teacher was unable to exploit this opportunity in this situation. This raises the question of how the teachers and children understand the concept of collaboration. In this situation, the teacher's intervention did not change the conditions of the children's collaborative process. Collaborative learning is therefore not merely a matter of instructing children to collaborate or seating them next to one another. An important requirement is to focus on different stages of collaboration and thereby teach children how to, and



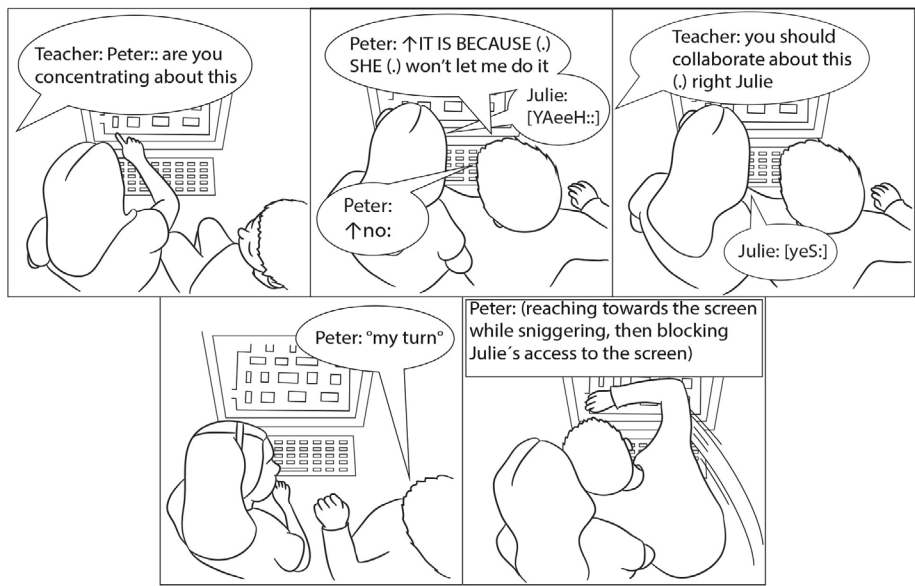


Figure 4. Peter and Julie working together.

why they should, collaborate. Hence, teachers must be aware of collaboration stages, both in action and design, to successfully integrate touchscreen-supported collaborative learning in classrooms.

Narrative case two: ‘The right answer is there, let’s find it’

Andy and Kate were composing sentences by moving words around on the touchscreen. Andy had created most of the sentences but experienced some problems with

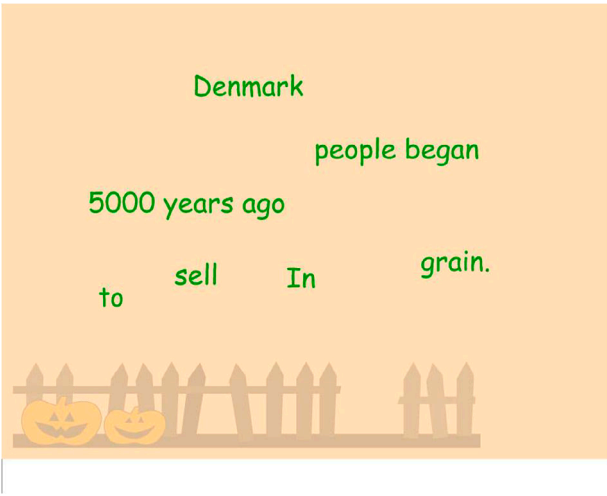


Figure 5. The task (translated from Danish to English).

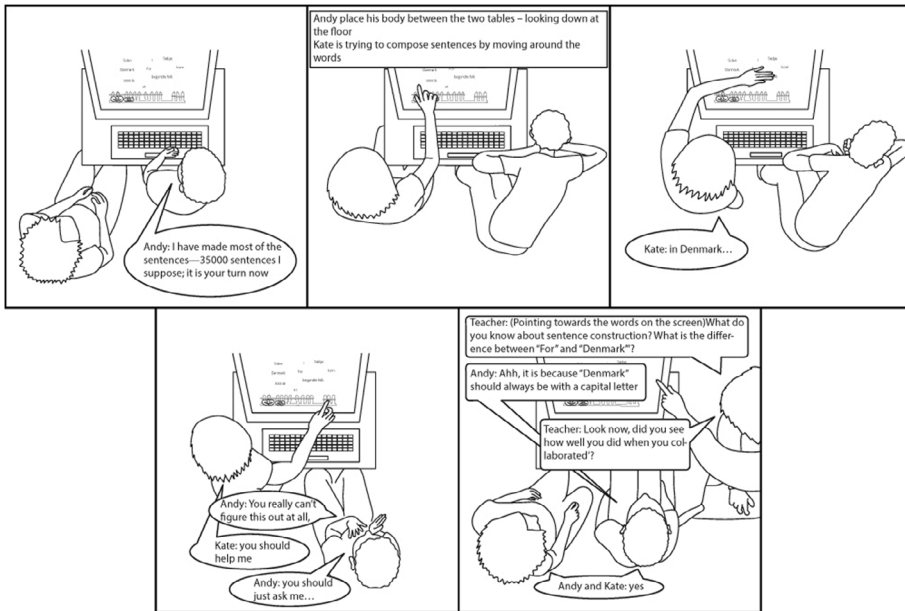


Figure 6. Andy and Kate working together.

a specific sentence. Both children were familiar with the general concept of sentence construction; that it begins with a capital letter and ends with a full stop. What triggered the children's frustration in this situation was the word 'Denmark'. Two words begin with a capital letter: 'In' and 'Denmark'.

Nevertheless, this was not an entirely new concept. Within the previous five minutes, Andy had constructed two similar sentences without articulating the concept of the proper noun. Andy told Kate, 'I have made most of the sentences – 35,000 sentences I suppose; it is your turn now.' Andy leaned forward and placed his head on the table, looking away from the screen. Kate attempted to solve the problem, moving the words around on the screen. For four minutes Kate explored different word combinations, but every time, she ended up with sentences that did not convey meaning. In her trial-and-error run, Kate kept her finger on a word on the screen, reading the current sentence out loud. When the sentence did not make sense, Kate moved the word away and tried a new combination. Kate did not succeed, and the children remained stuck. Given their social relationship and academic level, they needed guidance.

Andy raised his body, looking directly at the screen again and then tried to compose the sentence but also failed to accomplish the task. Before calling for help, Andy said to Kate, 'You really can't figure this out at all, right?' Kate replied, 'It's because you are not helping me out.' Then Andy decided to call for help from the teacher, Anne, saying, 'Anne, we cannot figure this one out at all.'

Anne walked over to the pair and sat down on the table to the left of Kate. Instead of solving the children's problem, Anne started asking questions about how to construct sentences: 'What do you know about sentence construction? Can you sort the words to get an overview? What is the difference between "For" and "Denmark"?'. For two minutes, Anne guided the children in their collaborative

inquiry, and they finally articulated and understood the concept. Andy said, ‘Ahh, it is because “Denmark” should always be with a capital letter.’ With the concept in place, Andy and Kate produced the correct sentence together with Anne.

Anne did not immediately leave the children. As a final comment, she said, ‘Look now, did you see how well you did when you collaborated?’ Both children said ‘Yes’ without further comment; although the pair experienced being partners in problem solving with guidance from the teacher, they continued their pattern of making individual contributions afterwards. The presence of the teacher appeared to be pivotal in establishing a shared understanding of the problem at hand and determining how to work together to solve it.

Interpretation

The purpose of this learning activity was to practise forming sentences whilst learning about the history of Danish agriculture (Figure 5). As in the first narrative case, the children did not work together without prompting from the teacher. Given that they simply took turns completing the tasks without interacting with or helping each other, their collaboration can be characterised as a division of contributions and articulation of individual perspectives.

Andy and Kate established social presence, which Murphy (2004) highlighted as a prerequisite for engaging in collaboration. Andy was more focused on telling Kate what she could not figure out than on engaging in a collaborative effort to solve the problem. As in the first narrative case, the social relationship between the children influenced their engagement in solving the problem together. The teacher’s intervention produced a different result; her presence and ways of asking questions fostered a learning situation for the children. As a general pattern of the guided interaction for the first two months, the teachers rarely stayed with the pairs of children for more than 15–20 seconds when they were using the touchscreens. They primarily provided children solutions or solved technical problems (e.g. correcting spelling or saving a file). One of the teachers described this initial period as one of ‘zapping’ or moving rapidly around amongst the pairs. The teachers’ interventions later transitioned into what we term ‘immersive guided interaction’, especially when facilitating the children’s collaboration.

The teacher in this narrative, Anne, attempted to establish a shared understanding of the problem for Andy and Kate, thus enabling them to reflect on the task and accommodate each other’s perspectives and meanings. Anne influenced the children’s collaborative activity; first, because she asked questions that compelled the children to articulate individual perspectives, and second, because her guidance established a shared conception of the task, which finally encouraged the children to solve the task together. Nevertheless, the ability to engage in collaborative problem solving appeared to highly depend on the social relationship between the children and on teacher guidance. In other words, although designing for collaborative problem solving is crucial, teachers’ embodied cultivation and facilitation of children’s collaborative problem solving in action should not be neglected.

Narrative case three: ‘Follow the plan’

Just after Easter, the children were asked to work in pairs on an Easter theme for four days. To guide the children’s activities, the teacher created a learning design

guided by a plan and consisting of several learning activities. Each activity was based on the children's work on a previous task.

Nathalie and Peter were paired together. As a whole-class activity, the teacher told a story about Easter and introduced the learning material. None of the children were paying attention to the final instructions. To begin, the teacher told the children to open the Notebook™ file and follow the plan indicated on the first slide (Figure 7). Instructions about operating the software were also provided. The teacher expected the children to work with this learning design for the next four days. After 21 minutes, Nathalie and Peter, similar to most of the other pairs, completed the work and reached the final slide (task) in the learning design. They missed half the text of their story, sped through the multiple-choice quiz by guessing, and created a 'nice-looking' picture instead of retelling the story by moving around the avatars available to produce a short video. Even though the teacher, Anne, told the children to return to the list of tasks after they completed each task, they never did. Anne interrupted Nathalie and Peter as they created their picture to tell them that they were progressing too fast. Nathalie and Peter were confused but, after being guided by Anne, they realised they had not completed all the tasks. Anne asked Nathalie and Peter to return to the list every time they were done with a task to highlight (colour) the task and then continue on to the next. For the next four days, Nathalie and Peter collaborated and used the plan the way Anne intended. Anne also learned that her list of tasks can be used as a guiding principle for the children's work, even though such an approach meant the children have to take a step back before they can move forward. The act of colouring the list of tasks served as an embodied resource for the children's ongoing collaborative activity.

Interpretation

The teacher had multiple goals with this learning design: the children should learn about Easter, build shared perspectives, negotiate meaning and produce a shared product. Overall, this lesson adhered to Murphy's (2004) collaboration model in terms of design. To promote a high degree of learner autonomy, the teacher designed a plan for the children to follow (Figure 7). The plan was intended to work as an auxiliary tool that supports the children's activities in terms of coordination and task management. As the narrative case illustrates, however, Nathalie and Peter followed a different path of activity, as did the rest of the pairs in the class. In other words, the auxiliary tool prompted a situated action other than that imagined and designed

- Easter Sunday**
- Use the text-to-speech program on the pages of text
 - Afterwards, you must read the copies of text with the history. Read it loud for each other.
 - You have to answer the questions.
 - Rehearse your retelling of the story together.
 - Write the retelling into your Danish book.
 - On the next page you must make a retelling of the story - you have to use the figures. You should use the "SMART recorder" to record your retelling.

Figure 7. List of tasks (translated from Danish to English).

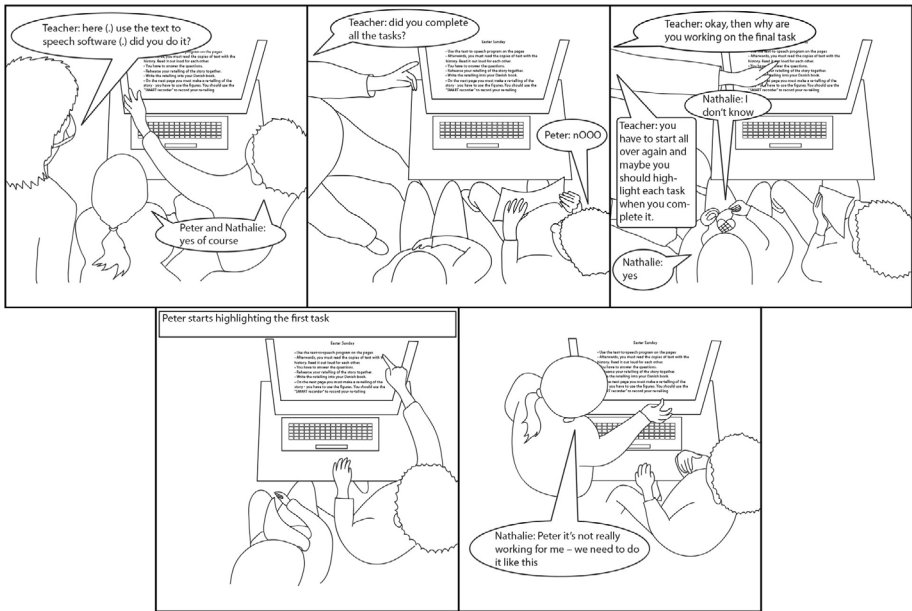


Figure 8. Nathalie and Peter working together.

for by the teacher. The structure of this learning design was not appropriated as a method or way of working (Wertsch, 1998), and the children acted as they normally would, continuing in a linear fashion from slide to slide. An important issue to remember is that this situation may not only be a matter of understanding and following the teacher's plan, but also a consequence of the affordances and constraints built into the software; it is characterised by a linear structure, rather than serving as a dynamic way of guiding interactivity. Although the teacher designed a plan that took the children through various stages similar to those of Murphy's model, the children were unfamiliar with this manner of working. This narrative case further illustrates the uncertainty that teachers must deal with in teaching; they should continuously accommodate and adjust learning designs and ways of guiding pairs by observing and analysing children's interactions.

Discussion and conclusion

With the narrative cases, we have illustrated how children use touchscreens for collaboration and how teachers design and facilitate collaboration in natural classroom settings. On this basis, an essential observation is that although collaboration is often a goal, it is nonetheless an unclear concept for teachers. Compared with laboratory studies wherein children work on tasks designed by researchers or software developers, the context of our study provides ecological validity to our findings. For example, the natural setting and our analytic strategy offer an understanding of the subtle details that make a difference when teachers instruct children to collaborate around touchscreens. In particular, our work illustrates how teachers can incorporate twenty-first century skills into teaching practice and adjust their understanding by participating in a collaborative research project.

By applying Murphy's (2004) collaboration model and the theory of embodied interaction to these three narrative cases, we have fulfilled this study's twofold research objective. We have presented and discussed the complexity of collaboration in terms of design and action for both teachers and children. In narratives one and two, the children made individual contributions, and their embodied actions were, to some extent, private in the shared workspace. That is, the children divided the given task into subtasks without working together. In narrative three, the children accommodated and reflected on each other's utterances and actions. The pairs constructed shared perspectives, and each child treated the touchscreen as a shared workspace. These three narrative cases present how children engage/disengage in collaboration through embodied interactions in the local ecology of semiotic resources. Equally important, the cases make visible the subtle processes that teachers should consider and incorporate when designing for and guiding children's collaborative activities in the classroom.

As previously established, although shareable and interactive technologies are being integrated into primary education classrooms worldwide, an as yet unaccomplished critical requirement is determining whether and how interactive surfaces can help children learn to collaborate and how teachers can support this process in design and action. Even though new technologies are becoming increasingly more intuitive and user-friendly, discussing how these technologies can be integrated into classrooms in a pedagogical fashion is crucial. In light of our findings, therefore, we propose that teachers should consider Murphy's (2004) collaboration model and the theory of embodied interaction analysis in developing learning designs for children's collaborative activities in the classroom. This consideration should include specific supporting technology and software. Likewise, in efforts to understand children's collaboration around touchscreens, embodied interaction analysis offers a holistic and context-sensitive approach that focuses on participants' 'mundane' activities in their local environments with the present semiotic resources at hand. Thus, our findings emphasise children's everyday embodied methods for engaging/disengaging in collaborative learning – methods that are often neglected by experimental studies. Amongst other contributions, our approach has enabled us to deduce that although collaboration is often a goal for teachers, it is difficult to implement in practice.

As the analysis of the cases has evidenced, Murphy's (2004) collaboration model can serve as a useful pedagogical tool in the design of digital materials for collaboration supported by touchscreens. Based on this model and our findings, we suggest that designs for collaboration should facilitate accommodation of and reflection on others' perspectives, co-construction of shared perspectives and meanings, and creation of shared goals and purposes. In addition, teachers must clarify what 'collaboration' is for themselves and for their pupils. In the narrative cases, simply repeating the word 'collaborate' did not necessarily promote higher levels of collaboration. Important tasks, therefore, are for teachers to guide pairs of children in a given situation and ensure understanding of the nature of collaborative learning as a process of meaning making through language, gestures and materials at hand. For instance, none of the learning designs in the narrative cases were comprehensively directed towards scaffolding collaborative activities. The children could have easily completed the tasks independently but were instead compelled to find a method for organising their collaboration.

Moreover, teachers should not facilitate and guide collaboration from a distance or as they ‘zap’ by, as in narrative one. Even though some argue that ICT will make the presence of teachers superfluous in classrooms, our findings suggest that teachers’ immersive and active participation in children’s learning activities is crucial to the outcomes of such activities. Teachers should act on moments that present learnable collaboration. Hence, developing teachers’ understanding of collaboration and embodied interaction at a theoretical and practical level is essential to teaching twenty-first century skills in the classroom, with or without ICT. This conclusion contrasts with the frameworks proposed by Beauchamp and Kennewell (2010) and Alexander (2008), which primarily delineate guidelines for teachers’ facilitation of classroom dialogue. We suggest that collaboration be framed within an embodied interaction perspective, which offers teachers a different and more detailed understanding of children’s embodied collaboration in terms of designing for and guiding children’s learning of collaborative skills. On the basis of the narrative cases, we argue that an embodied perspective can aid and support teachers in translating the abstract descriptions of twenty-first century skills into classroom practice. The narrative cases are examples of unravelling the visible, but unnoticed, details of children’s collaboration; the insights drawn from such examples can bridge the gap between research and teaching.

Although we promote the collaboration model and an orientation towards embodied interaction as valuable design and facilitation tools, some limitations characterise this approach. Contrary to Murphy’s (2004) sequential and linear model, the pairs of children in the narrative cases tended to collaborate in a more iterative fashion – going back and forth as they accomplished their work. The participating children often created shared artefacts without adopting each other’s perspectives or using the artefacts as materials to understand each other’s viewpoints. They exhibited understanding only in the phase of producing the shared artefacts. The analyses also suggest that facilitation of collaboration is a complex, situated and material matter; facilitating collaboration is an emergent learnable moment for children and teachers. In other words, several factors influence the collaborative process and the teachers’ abilities to guide children’s collaborative processes. These factors are not necessarily considered in macro-level policy frameworks. We propose that future studies continue to illuminate how teachers can integrate and accommodate twenty-first century skills in their classrooms, but also that they investigate the nano curriculum level (van den Akker et al., 2003) to inform the policies defined and described at the macro level.

Many of the existing studies on twenty-first century skills accord priority to collaboration and ICT, but these do not provide any concrete suggestions on how teachers can integrate collaboration and ICT into their pedagogical thinking and classroom activities, both in terms of designing for collaboration and facilitating collaboration in action. Presenting and analysing three narrative cases, we contribute nano-level empirical knowledge to existing abstract policy frameworks, thereby shedding light on how children’s collaboration around touchscreens unfolds and how teachers can design for and facilitate collaboration at the nano level. This study therefore initiates steps towards realising teachers’ integration of twenty-first century skills (e.g. ICT and collaboration) into their classrooms, both theoretically and empirically.

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Disclosure statement

No potential conflict of interest was reported by the authors.

Note

1. The authors changed the names of the school and all participants.

Notes on contributors

Dr Jacob Davidsen is an Assistant Professor at the Department of Communication and Psychology at Aalborg University in Denmark. He is affiliated with the eLearning Lab – Center for User Driven Innovation, Learning and Design. His research interests are in the field of computer-supported collaborative learning, learning sciences and multimodal interaction analysis. He publishes on these topics, both in international and Scandinavian journals. Dr Davidsen is methodologically experienced in qualitative research methods with a specialty in micro-multimodal interaction studies.

Dr Ruben Vanderlinde is an Assistant Professor and postdoctoral researcher (Research Foundation Flanders) at the Department of Educational Studies at Ghent University in Belgium. He is also a visiting research scholar at the Curry School of Education (University of Virginia), and at the ‘Internet Interdisciplinary Institute’ of the Open University of Catalonia (Barcelona). His research interests are in the field of educational innovation, teacher training and professionalisation, and the integration of ICT in education. He publishes widely on these topics, both in ISI-listed journals and more practitioner-oriented journals. Dr Vanderlinde is methodologically experienced in mixed-method research.

ORCID

Jacob Davidsen  <http://orcid.org/0000-0002-5240-9452>

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