"This Is the Size of One Meter": Children's Bodily-Material Collaboration and Understanding of Scale around Touchscreens

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Abstract: In CSCL studies, language is often foregrounded as the primary resource for engaging in collaborative learning, while the body is more often positioned as a secondary resource. In this paper, we present, analyse and discuss how two nine-year-old children collaborate through gesturing and moving their bodies around a touchscreen. The pair is working with the concept of scale and are in midst of copying their rooms from paper to touchscreen. During this process, the pair engages in a discussion regarding the size of one meter through language, gestures and manipulation of the material resource. The analysis shows two distinct ways of understanding the length of one meter, which primarily is visible through the children's gesturing and bodily movement. In conclusion, the analysis shows that children dynamically produce body-material resources for communicative and illustrative purposes; moreover, they use body-material as a cognitive tool and as a way of shepherding the other.

Keywords: touchscreens, embodied interaction, knowledge building, video analysis

"When the proportions of architectural composition are applied to a particular building, the two-termed relationship of the parts to the whole must be harmonized with a third term—the observer. He not only sees the proportions of a door and their relationship to those of a wall (as he would in a drawing of the building), but he measures them against his own dimensions. This threetermed relationship is called scale."(Britannica Online Encyclopedia, 2014).

Introduction

While already Vygotsky (1986) argued that gestures and body movements play a central role in children's communication and learning it seems equally evident that even in Vygotsky's own work language is considered the main vehicle for learning, communication and collaboration. Likewise, within CSCL, we would argue, language and tools (artifacts) have been considered the most important resources to study. We certainly do not wish to dispute the central role of language and artifacts, but we would like to emphasise the role of gestures and body movements as bodily-material resources which are also important in relation to communication, learning and collaboration. In this paper we present, analyse and discuss a short video excerpt (36 seconds) of two nine-year-old children's interaction and collaboration around a touchscreen. The excerpt is a small clip from a larger set of data (video, interviews, and observations) from a long-term research process and collaboration with a particular school over an entire school year. While we return to the context of the data the main purpose of this paper is to use a small example to illustrate the richness and complexity of the bodily-material resources in play in children's collaboration around touchscreens. Within this short duration of time we discuss how bodies and gestures are used as both communicative/illustrative, cognitive and collaborative resources, and we show how they are dynamically used to organise intra- and inter-psychological processes. In the example the children are working with 'scale' and we trace how they use both language and gestures to convey and negotiate their understandings of this concept. We argue that they use the bodily-material resources as 1) a communicative and illustrative resource for showing each other their understandings, 2) a cognitive auxiliary tool scaffolding knowledge building, and 3) a way of shepherding (Cekaite, 2010) and instructing each other. Further, we discuss how we view this as particular relevant to the (re)growing interest in co-located collaborative environments (Higgins, Mercier, Burd, & Joyce-Gibbons, 2011) within CSCL and how it adds to our current understanding of learning and collaboration. In brief, the interest in co-located collaborative settings has been instigated by the technological development of various multi-user technologies, such as tabletops and interactive whiteboards. Among other things, the possibility for several users to touch and manipulate objects on the screen simultaneously has been highlighted as a major benefit for collaborative learning. While researchers often emphasise that the possibility to touch is more direct than interaction through keyboard and mouse, we take the stance that the zone in-between children and touchscreen afford new conditions for children's bodily-material communication, collaboration and learning.

Theoretical and methodological orientation

In CSCL, language (written text and spoken utterances) and artifacts are viewed as the primary resources for engaging in collaborative learning activities online, face-to-face or in blended learning environments. Stahl argued that "*meaning is created across the utterances of different people*" (2006, p. 6 italics in original), and in a recent overview of CSCL Dillenbourg, Järvelä and Fischer (2009) stated that language is believed to be the primary resource for engaging in collaboration. Text (like other physical objects) is also considered as an artifact in the CSCL community, which can embody meaning or facilitate intersubjective processes of meaning-making (Stahl, 2006). CSCL has developed methodological and theoretical rich vocabularies for analysing and discussing the role of language in collaborative learning. Nevertheless, a group of CSCL researchers have argued that gesturing and body movements equally play a central role in establishing and negotiating shared understandings of problems (Davidsen, 2014; Greiffenhagen, 2011; Lymer, Ivarsson, & Lindwall, 2009; Roschelle & Teasley, 1995). Bonderup-Dohn (2009), taking a phenomenological stance on CSCL, argued that interaction should be viewed as a bodily phenomenon, yet, Bonderup-Dohn only provided a theoretical understanding of the body's interactional and cognitive potential. Likewise, Ingold (2014) eminently formulated the role hands in human interaction in a recent talk; "hands are the means of togetherness that is they are instruments of sociality".

In order to analyse how children use their hands and bodies to as resources for engaging in collaborative learning, we have applied embodied interaction analysis (Streeck, Goodwin, & LeBaron, 2011) to a short video excerpt. Rather than assuming language as the primary resource for collaborative learning, embodied interaction analysis focus on a triad of constituting semiotic resources; language, body and material. We use the video excerpt as an illustration of the importance of understanding children's gesturing and bodily collaboration around touchscreens – in the zone in-between, which opens a window to understanding children's embodied (bodily-material) methods of communication, collaboration and learning, e.g. how they use their hands and bodies as a means of producing situated understandings and as a means of thinking together around touchscreens.

Related work

Within the past 15 years, the CSCL community has been active in designing for and understanding collaborative learning around multi-user technologies, like tabletops and interactive whiteboards. This forms part of what Higgins, Mecier, Burd and Hatch (2011) characterised as a reorientation to collaborative learning in co-located settings. The various studies on tabletops revolve around one of the basic research traditions identified by Stahl, Koschmann and Suthers (2006); namely experimental laboratory studies. In this paper, we briefly examine the experimental studies to review some findings, methods and theories found in the body of related studies on collaborative learning around touch technologies in order to situate our work within the tradition of CSCL research.

Some of the general traits of the experimental studies are; laboratory settings, restricted/limited time frames, selected user groups and hypothesis testing. Some of these laboratory experiments have provided important findings on children's collaboration around tabletops; for instance, Harris et al. (2009) reported that children talked more about turn taking using single-touchscreen and that children were more task oriented in a multi-touch setting. While Rick, Marshall and Yuill (2011) suggested that enforcing equitable physical participation can disrupt the dynamics of collaborative learning. Finally, Higgins, Mercier, Burd and Hatch (2011) stated that multi-touch tables support collaborative interaction more effectively than the paper-based version of the task. Another common characteristic of the experimental studies is the methodological orientation towards coding and counting children's interaction by applying different theoretical models. For example, Mercier and Higgins (2014) applied two coding schemes; one for determining levels of reasoning and one for determining tabletop use (direct touches on the surface). By separating levels of reasoning and tabletop use, however, Mercier and Higgins enforced a split between language and body movement. The separation of language and movement might be a fruitful analytic distinction, but, as we shall show in the analysis, this can potentially leave out subtle details of the interconnections between thought, language and bodily-material resources in children's joint reasoning and collaboration. As observed by Vygotsky "Communication without action remains unintelligible (…)" (1986, pp. 52–53) for the child, and we suggest that these relations are important to scrutinize more carefully. Furthermore, we also argue that although 'direct touches' on the touch-screens are obviously important, it is equally important to understand bodily interaction and gesturing in the zones in-between the touchscreens and the children. As we will show this zone is important in terms of communication, collaboration and learning.

The "Move and Learn" project: Two children working with the concept of scale

The "Move and Learn" project was a technology integration project initiated by a Danish public school where two classrooms were physically re-organised with 16 single-touch screens and two interactive whiteboards. The school invited researchers (one being the first author) to follow the process. Throughout a year two researchers followed and worked with the school (Davidsen & Georgsen, 2010) and collected data in a variety of ways (e.g. 150 hours video material, observations, interviews, and screen-recordings). In the example we present and analyse, the children and teachers (1) had been working with the single touchscreens in their classrooms for about nine months and therefore had some experience in working together with the touchscreens.

The example stems from the final period of the "Move and Learn" project and the teacher had designed learning materials where the children were to collaborate on an assignment regarding the concept of scale (see Figure 1). As a final outcome of the children's work with the concept of scale they were to produce a multimodal story about their own room at home illustrating also their understandings of the concept of scale. The task involved two overall steps. First each child had to measure and draw their room on traditional squared paper. Second they had to draw their rooms together with a classmate using the touchscreen. While sitting together, the children had to go through three steps (see Figure 1): 1) Draw their respective rooms on the touchscreen together, 2) position the relevant objects (provided by the teacher) in the room and 3) finally record a multimodal story about their own room. Hence, the learning material designed by the teacher serves as an action- and information-space for the children (Figure 1). The design of the tasks did not prescribe how to collaborate. Hence, the children had to negotiate how to collaborate. While the task of converting their drawings from paper to screen was 'just' copying from one medium to another the children's translations from paper to touchscreen provide a demonstration of their individual understandings of scale and size of one meter.
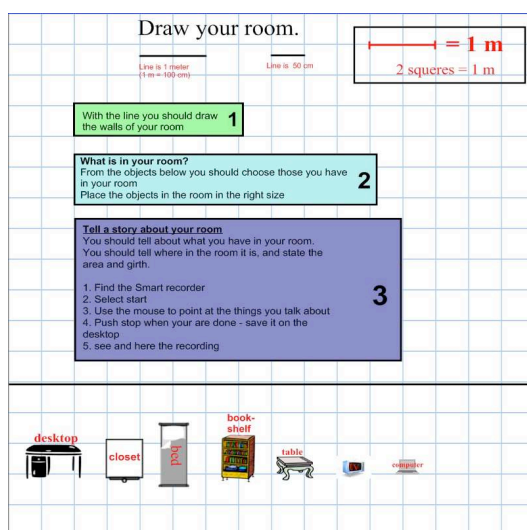

Figure 1. Learning material

Distributed over a week the children worked with the task in 5 sessions of 45 minutes. In total, 11 hours and 17 minutes of video footage were recorded with three different pairs working with this learning material. On this basis, we selected one situation (36 seconds) to illustrate how the children use bodily-material resources for communication, collaboration and learning. In the example we follow Natalie and Peter. Similar to the rest of the pairs in the classroom they have been working with the overall task for one week, and in the particular situation they are in the midst of transferring Natalie's room from paper to screen. The situation was transcribed using TRANSANA and ELAN.

Children demonstrating their understandings of one meter and the concept of scale

Below, in Figure 2 and 3, the chronological development of the children's activity is represented with transcripts and "pencil drawings" based on the original video footage. With the situation we want to illustrate different aspects of the children's ways of using gestures and movements, e.g. as a communicative and illustrative resource, as a cognitive tool and as a way of shepherding and instructing each other. Following the presentation of the children's activity, we analyse and discuss the findings in relation to CSCL on a theoretical and methodological level. The children's talk is either above the or next to the numbered pencils drawings. In our descriptions, we will be referring to the numbered drawings and talk as frame 1-14.
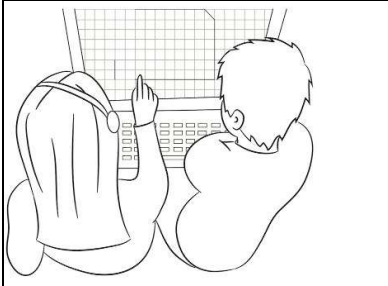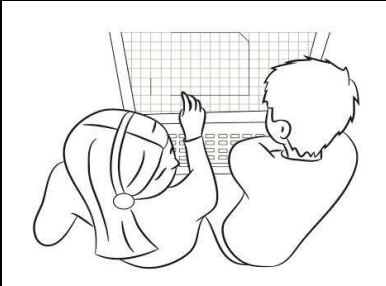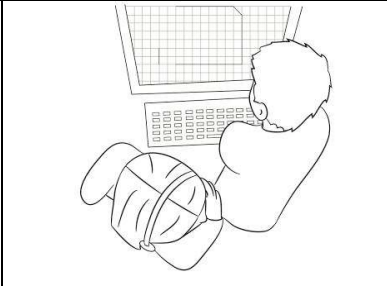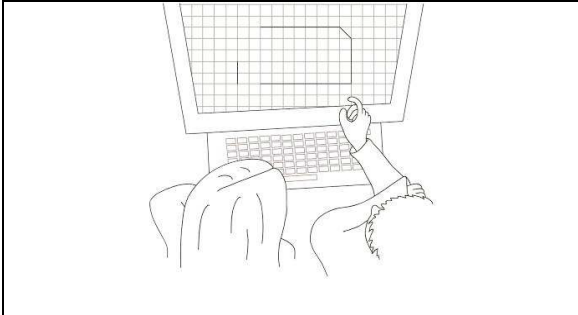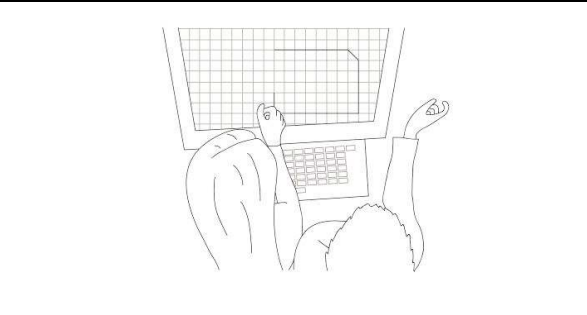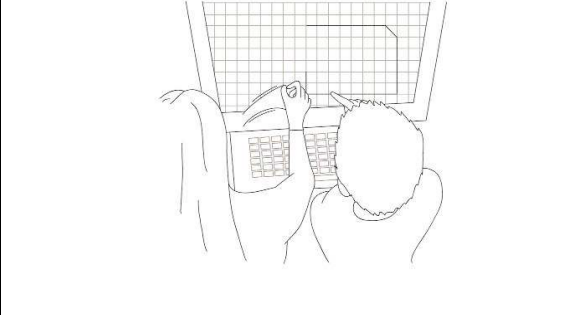
Teacher (not visible): so I believe it is correctly measured (.) it is THREE METERS in that direction		
P: noo:: (0.7)	it is a meter (0.2)	that is actually like this::
N: yearh:: right:: P: [it (0.2) it is two] (1.0) N: mmm (0.4) P: one meter (.) it is two of those there N: yes (0.8)		

Figure 2. Transcript part 1

At the outset of this situation, Nathalie is about to place the vertical line in connection to the horizontal line. She attempts to drag the line, however, the line does not follow, – in the same moment and movement she turns her torso and head right, looking away from the touchscreen and out into the classroom (attending possibly to the teacher saying out loud 'so I believe it is correctly measured (.) it is THREE METERS in that direction') – (frame 1-3). While doing so, Nathalie retracts her right hand from the touchscreen. In making her new body position, Nathalie does not finish her work on the touchscreen and the vertical line (wall) on the touchscreen remains in the same place. This serves as the basis for Peter's evaluation of her work (frame 4-5). Nathalie returns to her original body position (frame 4-5), and while Peter is evaluating her misplacement she stretches forth her right arm and begin to move the vertical line towards the correct position. Simultaneously, Peter stretches out his right arm and says 'noo:: (0.7) it is a meter (0.2) that is actually like this::' (frame 4-5) and shows his understanding of one meter with a gesture, e.g. the relation between two squares on the touchscreen by positioning his thumb and index finger as a way of indicating approximately one meter (two squares). At first Peter was gesturing in front of the touchscreen (frame 4); however, when Nathalie approached the touchscreen Peter smoothly moved his hand away from the screen to the right (frame 5). Peter maintains his gesture next to the touchscreen while Nathalie is correcting her misplacement. However, when Peter is saying 'that is actually like this::' and holding his gesture for 1.5 seconds, Nathalie looks briefly in the direction of his hand, but keeps moving the line. In frame (6) Peter keeps explaining his understanding of a meter, now shifting his gesture to pointing sequentially at two adjacent squares while saying 'one meter (.) it is two of those there'. All along Natalie is agreeing through verbal feedback (yearh:: right::, mmm, yes) while simultaneously moving the line, which is in the correct position as Peter says 'it (0.2) it is two'(however, she keeps fiddling with it until frame (7)). As a response to Peter's final comment 'it is two of those there' (frame 6), Nathalie agrees again with a

'yes'. In frame (7) Peter keeps explaining, but Natalie takes over the turn by raising her voice saying '[AND THAT] is why I say:' and she starts counting the length of the horizontal line using her index and middle finger.
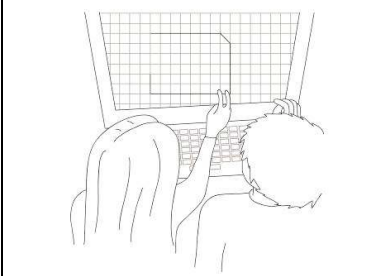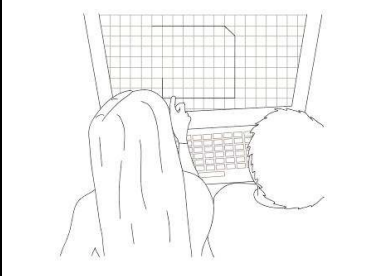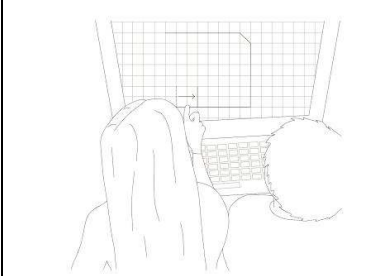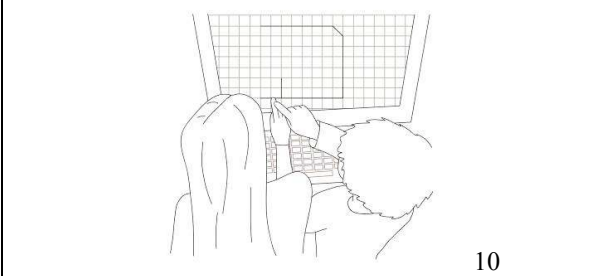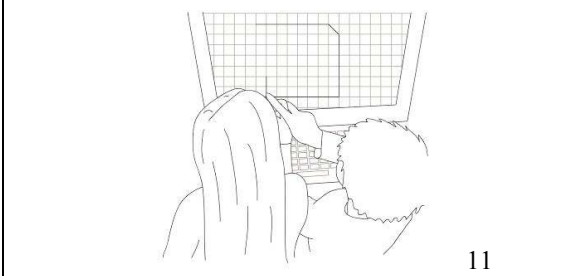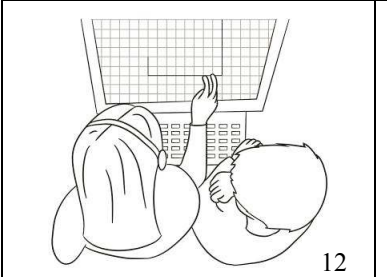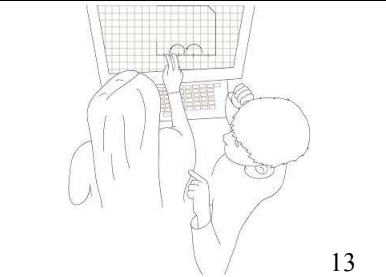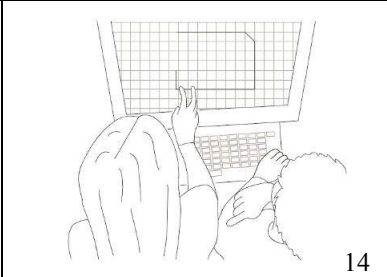
P: and you take

N: [AND THAT] is why I say: one:: (0.4) two:: (0.6) three:: (1.2) °°f::°°

P: nOO: (1.2) TWO (.) it is RIGHT that you put it there::

10

11

P: i don't know (.) WHY is that one falling down all the time (.) it is too big for you (.) that one falls down all the time

N: one two (.) three (2.0) four (0.6) there (0.4) it shall be placed:

12

13

14

Figure 3. Transcript part 2

From the transcript (frame 7-8), it is visible that Nathalie hesitates between three and four, and her fingers end up six squares into the line, rather than eight. While she is demonstrating her understanding and rationale to herself and Peter, she notices that something is not in order. Then she decides to move the vertical line from the correct position to a position two squares to the right (frame 9). The actual length of the line is now three meters instead of four. Peter evaluates Nathalie's work once again (Figure 7) saying 'nOO: (1.2) TWO (.) it is RIGHT that you put it there::' and then he moves his right hand close to Nathalie's (frame 10-11). Now Peter is shepherding (Cekaite, 2010) Nathalie's hand from the sixth square to the eight square. Compared to Peter's first evaluation, where he showed Nathalie his understanding of one meter with a gesture, he now moves his right hand close to Nathalie's hand and shepherd her hand to the correct position. However, Peter only shows Nathalie the right place of the vertical line and while he retracts his hand Nathalie moves her hand to the right and touches the vertical line and then moves it to the correct place.

After Nathalie places the vertical line in the correct place, the children start orienting themselves to two different things (frame 12-14); Peter starts paying attention to Nathalie's clothes as her blouse strap is falling down from her shoulder whereas Nathalie maintains her focus on the placement of the vertical line. While Peter is commenting on Nathalie's clothes, Nathalie starts to recount the length of the horizontal line by tapping on it with her gesture (index and middle finger). Nathalie is counting by nodding her head, moving her lips and

pointing to the squares on the touchscreen. In this situation, she is gesturing for herself, and trying to confirm that she placed the vertical line in the correct position, while Peter is oriented towards her blouse strap. She restarts her counting twice, possibly because being distracted by Peter commenting on the strap. The activity ends after Nathalie has attempted to count the line three times and finally reaches the end of the line saying and reconfirming 'there (0.4) it shall be placed'.

Discussion

It should be clear from the preceding section that gestures, body-positions and body-movements or what we term bodily-material resources play a central role in coordinating the children's interaction and collaboration (as does language of course). It seems that there is a closely knitted mesh between the bodily-material resources and language in these situations. There are no signs of language being more important for their coordination than the body-material resources, and much of the interaction would not be intelligible if we looked only at the utterances. This, however, is often the case in human interaction around artifacts, but as we shall argue the role of the bodily-material extends beyond interaction and communication. In the following we therefore "zoom out" slightly and offer a more analytic and interpretative perspective on their interaction and the relations between collaboration, learning and bodily-material resources. As mentioned initially, we see three distinctive ways of using bodily-material resources: 1) as a communicative and illustrative resource for showing each other their understandings, 2) as a cognitive auxiliary tool scaffolding knowledge building, and 3) as a way of shepherding (Cekaite, 2010) each other.

Bodily-material resources for communication and illustration

Throughout the activity, Nathalie and Peter move their hands and body to communicate and illustrate their understandings of scale and one meter, as well as to coordinate their work. For example, Peter produces a gesture (frame 4-5) to communicate his understanding of one meter to Nathalie – and seemingly not aware she is correcting her misplacement or unsure of her reception of his intentions he also points to the screen while saying 'two of those there' to emphasise that one meter is equal to two squares. Natalie does something similar immediately after where she says 'Yes, and that is why I say, one, two, three' and she starts to illustrate, how she has come to the same conclusion (frame 7-8). It is equally interesting how they mobilise their bodies as part of the work. In this particular example their movements are in sync and they follow each other like dance partners. This is difficult to convey in the transcripts, but in frame 4-5 where Nathalie returns to the screen her arm comes in over Peter's head and he, with an elegant sway, moves his hand to allow her room. Likewise, though they are seated quite close, they don't bump into each other or seem to be fighting over the space. Rather they leave room for each other (particularly Peter). This, however, when looking more broadly at the collected data material is not always the case. In fact, Peter appears in another analysis (Davidsen & Georgsen, 2010) at an earlier period in the project. In that situation he collaborates with another girl, where they physically push each other's hands and bodies away as to gain screen-control. Thus, and particularly perhaps for children collaborating around shared artifacts, coordination and collaboration concerns not only the verbal interaction and 'turn-taking', but equally bodily-material cacophonic or harmonic 'dances' between the participants.

Bodily-material resources for cognition

While the use of bodily-material resources for communication and illustration is prevalent throughout the activity, the gestures, we argue, also serve other means; namely as cognitive auxiliary tools (Vygotsky, 1986). Peter's gesture using thumb and index finger to approximate what 'a meter is' on the screen can be seen as such a cognitive auxiliary tool. However, this is most prominently displayed by Nathalie's two-finger counting system where she uses her index and middle finger to count. We interpret it as both a spatial, as well as numerical tool – spatially her two fingers occupy (if held correctly) the same space as two squares, and simultaneously the 'two' fingers can serve as a numerical reminder that it is 'two squares' that equals one meter (on the day before she does count four squares and assume that to be four meters, but is corrected by Peter). In this sense it can be interpreted as a specialised or custom-made tool that orients to or is conditioned by the particular design for learning (the work space provided by the teacher). Hence, Nathalie and Peter are using their hands in mobilizing and producing new (though ephemeral) semiotic resources (Goodwin, 2000) through their distinct ways of gesturing (or perhaps re-iterating or repurposing gestures that have been employed in similar situations). As can be seen from their interactions these tools are both 'personal' (they use different gestures), but also 'public' i.e. communicative/illustrative. In fact, in the first instance where Nathalie starts counting and makes an error causing her to misplace the vertical line (although she placed it correctly) could be interpreted as a transformation happening midways in-action from public, illustrative tools towards personal, cognitive tools. She initiates the turn by saying "Yes, and that is why I say" and starts visualising to Peter her

line of reasoning, and how she arrived at the placement. It, however, results in an error, as she seems to be illustrating more than really 'counting' i.e. it seems a more outward-oriented action. In contrast when she, shortly after, returns to re-count, it is done as what seems a more 'inward-oriented' activity. She is nodding her head simultaneously and moving her lips with no sound, and re-starting the count twice as perhaps disturbed by Peter's attention shift towards her blouse strap. In addition, their various gestures also demonstrate that they seem to have understood the notion of scale, and that 'something else' can represent one meter in their actual room, and that these relations can be expressed in a number of ways: squares on paper, on a screen, as an approximated gesture (Peter's thumb and index finger), tapping two squares or Natalie's middle-index finger 'counting device'. In fact, in the short clip, there are a number of different 'meters' present in different modalities that they seem to shift more or less seamlessly between.

Bodily-material resources for shepherding

Whereas we see a couple of situations where the children use bodily-material resources for communicative/illustrative purposes and as cognitive auxiliary tools, we only see one situation where their bodily-material resources are used as a way of shepherding or instructing the other. In frame 10-11, Peter is saying 'nOO: (1.2) TWO (.) it is RIGHT that you put it there::' and moving his right hand towards Nathalie's and together they move their hands left, right above the correct position of the vertical line. This particular moment, movement and touch shows how hands and language mutually constitute each other, and particularly how hands can be used as a resource for shepherding the other. Nathalie, then, swiftly moves her hand away from Peters and moves the vertical line to the correct place. He is showing her the right place, while she is moving herself and the vertical line to that place afterwards. In a way this movement seems to extend our discussion of their bodily conduct. There are different ways of bodily intervening with each other's space (and limbs), and that this might also form part of what a fruitful collaboration is or can be.

Embodied interaction in the zone in-between

Having presented, analysed and discussed the children's use of body-material resources for communication, collaboration and learning; we would furthermore emphasise that the space in-between children and the touchscreen serve as an important space for these processes to unfold. Thus, we suggest that what take place in-between the children and the touchscreen is of crucial importance when trying to understand children's collaborative activities in such a setting. While, it is obviously useful to look at the direct interaction with the screens, we would argue that there are two other kinds of interaction that are of interest. For one thing, we have pointed out that much of their coordination, communication and collaboration is sustained by movements, touches and gestures not directly interacting with the screen, but rather is performed in the open space in-between (space between the screens and the children, but also the space in-between the children). Secondly, we would point to what we could call in-direct interaction or simulation of touch. These are points in time where they are not actually touching the screens, but 'hovering' in front of the screen (as Natalie is counting or Peter tapping/pointing to squares). Thus, if we rely mainly on analysing the moments where they physically touch the screens (as this is recorded by the software) we should be conscious of what we might be missing. We therefore suggest that including the zone in-between can provide a more holistic understanding of communication, collaboration and learning around touchscreens.

Conclusion

Our main purpose in this paper has been to illustrate that bodily-material resources are important in relation to understanding CSCL, and particularly of course the notions of collaboration and learning. By presenting the situation with Nathalie and Peter we have provided a glimpse of their methods of engaging in collaboration around touchscreens through language and body-material resources. The children's language, gesturing and movement serve as resources for their individual and shared emergent understanding of 'scale' and the length of one meter, e.g. they are using their hands to produce situated understandings (Streeck, Goodwin & LeBaron, 2011) and as a means of building knowledge together (Stahl, 2006). As we have shown, a heightened analytic sensitivity towards bodily-material resources can uncover some perhaps otherwise unnoticed and subtle details of collaborative learning. While we have provided insights on the role of bodily-material resources in collaborative activities around touchscreens, we have also experienced some difficulties of making visible the dynamic and simultaneous gesturing and movement. Hence, there seems to be a potential for CSCL researchers to understand the dynamic simultaneous unfolding of embodied interaction to advance theory and method of the research field. For example, it could be interesting exploring in a more longitudinal perspective the genesis and development of Natalie's two-finger gesture. How does this emerge, do others adopt a similar practice or is she adopting it from someone else (e.g. the teacher). How does their bodily conduct develop over time, can we trace

changes in the way they occupy or intervene in each other's space, and what would this tell us about developing collaboration 'skills'. A deep and detailed focus on such short-lived moments of interaction can help us understand otherwise unnoticed subtleties and details of collaboration and learning, while a coupling with a more longitudinal perspective can help us trace the development or the longer-term influences on learning.

Endnotes

(1) Names of each child, teacher and the school have been changed to secure their identity.

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