View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Agder University Research Archive

Mathematical Learning Opportunities in Kindergarten through the Use of Digital Tools: Affordances and Constraints

Martin Carlsen

Abstract. This study aims at scrutinising the mathematical learning opportunities of children engaging with digital tools and the emerging affordances and constraints faced in such settings. By adopting a sociocultural perspective on learning and development, the multimodal analysis of the adult–child interaction shows that the children are participants in processes of appropriating the mathematical concepts of sorting and counting. Affordances are taken advantage of by the adults and constraints causing didactical dissonance are overcome and transformed into didactical harmony.

Keywords: Appropriation, Digital tools, Kindergarten, Mathematics

Introduction

According to OECD (2006), Norwegian kindergartens are educational institutions situated within a social pedagogy tradition as opposed to a "ready for school" approach. The enterprise of the kindergarten thus comprises play, care, and learning. During the last decade, mathematics has gained increased emphasis in curriculum documents related to the kindergarten context. The Norwegian Ministry of Education and Research (2006a) launched a framework plan in which mathematics for the first time was addressed as a separate domain. Norwegian authorities (Ministry of Education and Research, 2006b) have also emphasised the importance of implementing the use of ICT in the kindergarten to nurture children's development of digital literacy (see Buckingham [2006] for an in-depth analysis of digital literacy). However, these documents do not explicitly address issues regarding how to orchestrate mathematical activities through the use of digital tools.

In 2010, a project called 'ICT supported learning of mathematics in kindergarten'[i] was initiated at the University of Agder (UiA). In the project, two colleagues and I collaborated with kindergarten teachers in their orchestration of digital tools to foster children's mathematical learning processes (Hundeland, Erfjord, & Carlsen, in press). Both web-based applications and DVD-based software were explored and used with interactive whiteboards (IWB) and computers. In our work we were inspired by the argument of Plowman and Stephen (2003) and Sarama and Clements (2004), that research is needed which aims at identifying the role that digital tools may play and how such tools may contribute to

mathematics learning. This argument was repeated by Goodwin (2008), that research is lacking in the intersecting areas of mathematics, kindergarten children and use of digital tools.

A national survey in Norway with respect to children zero to six years old and their experiences with digital tools (Guðmundsdóttir & Hardersen, 2012) showed that these children live in a digital universe and they have experience with a broad spectrum of digital tools. My hypothesis is thus that kindergarten children may gain from their experience and engagement with digital tools as regards their learning of mathematics. The scope of my study is to investigate the possible mathematical learning opportunities which emerge when children engage with digital tools in the kindergarten, and the role of the adult(s) in that respect.[ii] More specifically, the following research question has been formulated for the present study: In what ways does use of digital tools in kindergarten give mathematical learning opportunities with respect to sorting and counting?

Theoretical framework

In this study I adopt a sociocultural perspective on learning and development, a theoretical stance originating from the work of Vygotsky (1978, 1986) and later socioculturalists such as Rogoff (1990, 1995), Säljö (2001, 2005), Wells (1999) and Wertsch (1998). Within this stance the notion of appropriation is used to denote the process of learning. According to Wertsch (1998), appropriation is a process of "taking something that belongs to others and making it one's own" (p. 53). Furthermore, Rogoff (1995) describes appropriation as occurring in the process of participation in a sociocultural activity "as the individual changes through involvement in the situation at hand" (p. 153). Appropriation is hence fundamentally intertwined with participation in collaborative practices (Vianna & Stetsenko, 2006). As argued elsewhere (Carlsen, 2010) in order to be involved in a process of appropriating a mathematical tool such as the number concept, the child has to be involved in a joint activity with more capable peers. The child also has to establish with peers a shared focus on what to pay attention to in tasks involving the number concept, and develop with peers shared meanings of the concept and appurtenant mathematical ideas. Furthermore, the child has to identify relations between her individual sense of the concept and the lexical meaning of it. Eventually, the child has to be involved in a process of transforming, i.e. to appropriate utterances and actions made by fellow children and adults in collaborative settings, and apply these in future activities (Moschkovich, 2004; Rogoff, 1990; Radford, 2002, 2003; Säljö, 2005).

The use of cultural tools, such as web-based mathematics applications in institutionalised settings, carries affordances and constraints when viewed from the user's perspective. According to David and Watson (2008), 'affordance' is a notion denoting "the possibilities for interaction and action offered in a classroom" (p. 32). Constraints are, accordingly, the "norms, effects and relations which limit the wider possibilities" (p. 32). Thus, affordances open up for interaction and action while constraints restrict interaction and action. I adopt these notions to analyse the affordances and constraints of the children's participation in a kindergarten setting, and how these affordances and constraints unfold as related to the quality and level of difficulty of the applications, technical issues, the children's behaviours, and child-adult interaction.

The multimodal nature of the children's interaction is crucial when it comes to their opportunities to appropriate the mathematical tool. From a theoretical point of view, the accompanying modes of interaction such as dialogue (Linell, 1998), gestures, body movements, nodding, and gaze (Radford, 2003; Roth, 2001) are seen as fundamental when analysing the appropriation process. In a study of kindergarten children's processes of appropriating number concepts by way of multi-touch technology, Ladel and Kortenkamp (2013) argue that the digital tool the children interact with significantly supports their externalisations of thinking. The digital tool becomes a tool for externalising thoughts and ideas related to both cardinal and ordinal aspects of the number concept. In their study, Ladel and Kortenkamp view the process of learning (mathematics) as involving the use of gestures. The digital tool these authors use affords touching and manipulations of screen objects. Gestures thus are naturally used by the children to make their mathematical thinking explicit. Research on the role of gestures (e.g. Goldin-Meadow, 2009; Radford, 2003; Roth, 2001), shows that gestures are used by children as mediating tools in order to communicate and emphasise ideas and thoughts.

Researchers such as Vangsnes, Gram Økland, and Krumsvik (2012) have shown that when commercial educational computer games are used in kindergartens, a didactical dissonance emerges between the game's learning space and the learning space which the kindergarten teacher seeks to achieve. In their study, Vangsnes et al. reveal that the studied kindergarten teacher found it problematic to realise her aims in using the game, due to the game's nature and internal didactical dispositions. In my study, the issue of didactical dissonance is not as striking as in the study of Vangsnes et al. In the study presented here, the web-based applications engaged with are argued to differ in nature from what Vangsnes et al. call commercial educational computer games. In my study, the adults orchestrate the

children's engagement with an application designed for mathematical learning, which enables didactical harmony. However, we will see that the adults take active roles in their interaction with the children in order to overcome the didactical dissonance. The adults focus on specific mathematical learning goals to make the children's interaction with the digital tool a mathematically meaningful learning activity.

Methods of data collection and analysis

The study presented here is of a qualitative nature (cf. Cohen, Manion, & Morrison, 2011). One basic assumption for my research was to study what happens when children interact with digital tools in a kindergarten setting. Two sessions lasting approximately 30 minutes each were videotaped in which four children five years of age, two girls and two boys, participated and were engaged with digital tools. The two boys worked collaboratively with web-based applications on a portable computer with a mouse, and the two girls worked collaboratively with web-based applications on a computer with touchscreen, however in separate rooms. The reason for dividing the children into two homogeneously composed groups with respect to gender was that the two boys were friends and the two girls were friends. No particular reason was given concerning which group was to use the various equipments. A pragmatic decision was taken that one group had to use the portable computer and the other group had to use the touchscreen. In both sessions, the children interacted with an adult who orchestrated the activities, i.e. he set up the activity with computers, guided the sessions, commented and asked questions to the children and so on. All four children had previous experience with using computers, but none of them had engaged with the particular applications that were used for this study. Naturally occurring talk-in-interaction was thus video recorded and transcribed in detail.[iii] This was done to serve an in-depth analysis of the interaction and collaboration involved in the children's processes of appropriating the mathematics implicitly present in the applications.

The digital tool the children engaged with for this study was a digital learning resource associated with a Norwegian mathematics text book called Multi (http://web3.gyldendal.no/multi). Both the boys and the girls interacted with applications designed for Norwegian second graders. This means that the children worked with mathematical tasks originally meant for children who are two years older than they were. As will be evident, the children are able to interact with and solve the mathematical tasks when competently supported by the adults.

The analytical approach I am adopting for this study is partly similar to that of Lantz-Andersson and Linderoth (2011). I am taking a multimodal approach (Radford, 2003; Roth, 2001) to the analysis of video data. The basis for my analysis has thus been that every utterance gets its meaning from its positioning in a sequence of utterances, i.e. each utterance ought to be interpreted relative to preceding and consecutive utterances. Furthermore, the utterances are parts of a jointly constructed dialogue made and experienced by all contributors (Linell, 1998). However, both verbal and non-verbal contributions complement each other, and therefore multimodal analyses are made regarding the role of the children's verbalisations and gestures when interacting with each other, the adult, and the digital tools. This combined approach encompasses the view that the interaction occurring amongst the children, the adult, and the computer is in essence multimodal. Moreover, the affordances and constraints within this multimodal process of interaction are considered when analysing the children's plausible opportunities when using digital tools in the kindergarten context.

Analysis and results

In the following excerpts, the children interact with web-based applications related to the mathematical theme of descriptive statistics, i.e. in this case sorting and counting. However, the children need to make sense of the multimodal nature (cf. Roth, 2001) of the applications, with text, diagrams, number symbols, pictures of toys, and movement. Moreover, the children have to relate to each other as well as the comments and questions by the adult. Excerpts will be presented originating from two settings: (a) two boys and an adult are interacting with the application, with the part called "Column diagram" at difficulty level 1; (b) two girls and another adult interact with the application, with the part called "Falling toys" at difficulty level 3.

In the following excerpt, the boys are engaged with an application displaying a diagram and symbolic toys to sort; see Figure 1. The children are supposed to sort the bricks according to their colour and relocate them in the columns to the right. In Norwegian the word "bricks" is written, even though the displayed geometric shapes are coloured squares. After sorting the shapes, the children may press the OK-button to check whether they have done the sorting correctly. The dialogue below, lasting two minutes, involves Leo, the adult, and the two boys John and Jack. Leo's goal for engaging the children with this application was for them to use the digital tool to experience sorting, counting, and realise the numerical relation between number and associated numerals.

Figure 1: A web-based sorting activity, level 1 (Author's translation in the text box) (http://web3.gyldendal.no/multi/1-4nettoppgaver/multi2a/kapittel3/oppgaveA/nivaa1)

Excerpt 1: Making sense of the application

Excerpt 1

In this excerpt it is evident that a learning activity is initiated by Leo when he starts by explaining what to do with the application (1). Leo situates the activity as being about estimating the number of squares of different colours and sorting the squares according to colour. John makes sense of the instruction and he answers Leo's question immediately (2). The strategy for counting the green squares cannot be detected explicitly from the video. However, I interpret the video as indicating that John is exemplifying the phenomenon of subitizing (cf. Fisher, 1992), i.e. the phenomenon that a person may only by a short gaze estimate a number without counting one by one. However, it might be that John is counting by moving his gaze, since he is neither pointing at the squares with his finger nor with the mouse cursor. This situation is repeated for all three colours (2, 3, 4, 5, 6).

Then the dialogue continues, directed towards the sorting and stacking activity of the squares (7, 8, 9, and 10). Based on his actions, John (8, 10, 12) has no difficulties with the sorting of squares according to their colour. However, he seems to have some technical-motoric difficulties with the physical displacement of the squares. After finishing the stacking of squares in the columns, Leo seeks to focus the attention on the correspondence between the number word *two* and the numeral *2*, and he asks whether John can locate the numeral corresponding to *two* (13). At first, John has difficulties in locating the numeral *2* amongst all the keys, since some seconds go by without any action (14). Eventually, he externalises that he has appropriated some ordinal aspects of the number concept, because he makes explicit that he knows that *2* is next to *1*. From the context it is reasonable to interpret this utterance as revealing his knowledge of these numerals as located next to each other on the keyboard (as the corresponding number words are next to each other in the number series). When he has located the numeral *2* (16), it is easier for John to locate the numerals *3* (18) and *4* (20).
In this excerpt we see how the adult orchestrates the learning activity by using the application as a mediating tool to communicate and interact with the children. From the outset it is apparent that the adult is dominating the conversation. The child contributes solely with short

oral statements. However, the child's contribution first of all takes place as actions with the mouse, stacking the squares by dragging and dropping. In spite of this, a dialogue as a medium of learning is jointly achieved by Leo and John. The affordances emerging through the use of the digital tool are, I would argue, prevalent features (cf. David & Watson, 2008). The digital tool affords opportunities for interaction, foremost between the adult Leo and one of the children John. It is evident that John is using the application as a digital tool to solve the task, to estimate the number of squares in different colours and to sort them accordingly. Moreover, several of the questions, prompts, and comments by Leo suggest that John carries out actions. Affordance is also predominantly due to the multimodal nature of interacting with the digital tool (cf. Roth, 2001). When it comes to the interaction amongst the children with respect to the digital tool, the excerpt above shows a constraining feature. Even though the application does not per se constrain interaction between the children, engaging with the digital tool by using a data mouse constrains interaction amongst the children as well as action by the other child, Jack. The person who steers the mouse is the one who actively engages with the digital tool(s). Constraining features are also related to the limitations of the digital tool per se. In many respects, the digital tool focuses on closed tasks and questions, leaving a scant space for problem solving. The dominant role of the adult in this case may also be seen as constraining the interaction, making fewer opportunities for the child(ren) to engage freely with the digital tool. However, Leo's efforts and interaction with the digital tool also intentionally focus on the mathematical ideas of sorting, number, and counting. Digital harmony and prolonging of the inherent didactics of the digital tool affords John's process of appropriating these mathematical concepts.

In this short excerpt we observe that Leo is using explicit gestures, pointing and sliding, to complement his oral instructions and explanations (cf. Goldin-Meadow, 2009; Ladel & Kortenkamp, 2013). However, John's gestures are of an implicit nature as his gestures are mediated by the use of the data mouse. John points to the various squares with the mouse cursor rather than pointing with his finger. In this sense the application implicitly affords the use of gestures. Moreover, the implicit gestures become actions John carries out to answer the questions and prompts by Leo.

Excerpt 2: Further engagements with the tool

The two girls, Ann and Judy, interacted with the same application as the boys, but in a separate room. The session was orchestrated by an adult, Kai. Kai judged that level 1 was

quite easy for the girls and maybe not challenging enough. He thus made the decision to continue their interaction with the application using the part called "Falling toys" at level 3. In this way, Kai actively took part in increasing the mathematical learning opportunities on behalf of the children, by employing the affordances intrinsic in the applications. Kai's action was closely related to the activity's goal of letting the children through the use of the digital tool experience counting, the numerical relationship between numerals and the appurtenant number, as well as making sense of the table and the diagram. As seen in Figure 2, the children are now supposed to combine their sense-making of the table to the left, including the different numerals, and their sense-making of the diagram to the right. We also observe that the number span is increased from 0–5 till 0–10. Since the children are unable to read the text at the top (within the text box) and the text in the table (*leke* = toy, *antall* = number), Kai informs the children what they are supposed to do. Physically, both girls sit in front of a computer connected with a touchable screen which the girls use directly to solve the mathematical tasks. They tapped the falling toys with their fingers, and then the toys were removed into the corresponding columns. The activity is thus about realising what number the numerals in the table indicate, and to match that to the number of toys being stacked in the columns as they tap the falling toys. The dialogue lasted for about two minutes.

Figure 2: An advanced sorting and counting activity (Author's translation in the text boxes) (http://web3.gyldendal.no/multi/1-4nettoppgaver/multi2a/kapittel3/oppgaveC/nivaa3)

Excerpt 2

Kai (61) initiates this dialogue by telling the girls that this particular application is really difficult due to the big numbers included (potentially up to ten, but in this particular case eight is the largest number). However, based on the girls' subsequent actions and utterances, the inclusion of relatively large numbers does not make the application difficult. They do not explicitly respond to Kai's comment. Instead, Judy (62) starts to do what she is supposed to do with this application, to tap her finger on the falling toys in order for them to be stacked in the columns. Kai (63) realises that at least Judy seems to know what to do here, and he confirms that she acts according to the task. Judy (64) confirms that she knows what to do, and she makes her thinking explicit in (66) where she explains that they need six bottles to

make the column(s) and the table correspond. Her gesture in this respect, pointing at the correct column, functions as an externalisation of her thinking. Her gesture in this case makes explanatory words superfluous (cf. Goldin-Meadow, 2009).

The next passage of the dialogue (67–76) concerns Ann's apparent difficulty in mastering the finger tapping of the falling toys. She does not precisely hit the falling toys and taps her finger on the column where the planes are supposed to be put. Eventually, she masters it, after recommendations by both Kai and Judy, and gets positive feedback (73). Then Judy (74) starts to tap the falling toys, even though it is Ann's turn. I interpret this as Judy showing her eagerness to interact with the tool. She also says that she wanted to help Ann do the necessary actions. This interaction is afforded due to the children's engagement with a touchable screen, and would not have been possible in the boys' case in excerpt 1. A touchable screen affords collaboration. Ann does not comment on Judy's interventions, but Kai (75) makes it clear that it is currently Ann who is supposed to do the tapping. Ann does not make any oral statements, but her actions (76) indicate that she has made sense of the functionality of the application and she uses it as a tool to sort and stack the various toys. Judy (77) then externalises her thinking by making explicit how she makes sense of the table within the application. They are to get six bottles, eight airplanes, and six teddy bears stacked in the columns. Kai (78) confirms that Judy is right before he makes the children aware that they constantly have to compare the number of toys they have so far stacked in the columns with the numbers in the table. Judy (79) then counts the number of bears by synchronising the tempo of her counting with nods of her head. The one-to-one correspondence as a fundamental aspect of counting and the cardinal aspect of the number concept is in this way made explicit. Judy's gesture supports her oral statement (cf. Goldin-Meadow, 2009). The gesture and the voice thus mediate the same mathematical idea. Kai (80) elaborates on the situation by asking about the number of bottles stacked. While he asks the question Ann continuously taps the falling toys, making the number of toys in each column equal. Ann (81) counts the number of bottles by moving her gaze (since she is neither nodding her head nor pointing with her finger), and she furthermore repeats the last number word reached. This indicates that Ann has made sense of the cardinal aspect of the number concept (cf. Ladel & Kortenkamp, 2013). Kai (82) then summarises his impressions from following the girls' interaction, and he concludes that the girls are good at mastering the digital tool.

By changing the level of difficulty and the exact application for the girls to engage with, Kai takes advantage of the affordances offered by the tool, in order to challenge the children and

create a learning activity in which both girls have opportunities to participate with their ideas and actions. The role of the adult is that of the more capable peer and thus crucial in order to develop the tool's implicit learning opportunities. Constraints are faced in this excerpt too, as the application does not allow for more than one person at a time to interact and carry out actions. In spite of that, I interpret the girls' interaction with the digital tool, showing eagerness and dedication, as indicating that they want to master the tool and deal with it accordingly.

Discussion

In this study I set out to come up with possible answers to the research question: *In what ways does use of digital tools in kindergarten give mathematical learning opportunities with respect to sorting and counting?* As we have seen from the analyses of the dialogues above, interaction and engagement with the web-based applications nurtured the children's processes of appropriating the implicit mathematical ideas and concepts (cf. Moschkovich, 2004). The digital tools to engage with were carefully chosen by the adults in accordance with their mathematical learning goals. The adults aimed at letting the children use the tools to experience sorting and counting, and numerical relations between numerals and appurtenant number. From the analyses we see that the children were jointly involved in a process of establishing shared meanings and making sense of the mathematics by transforming their actions with the digital tool to make sorting and counting their own (Rogoff, 1995; Wertsch, 1998). As seen from the dialogues, the children demonstrate their sense-making of the issues of subitizing, one-to-one correspondence and cardinality (Fischer, 1992). They also show that they make sense of numerals and their numerical meaning. Moreover, the children's opportunities to sort and count the squares and toys were afforded by their interaction with the digital tool and its multimodal nature (cf. Roth, 2001). The use of voice, use of gestures such as pointing and tapping, body movements such as nodding and manipulation of screen objects thus support the children's externalisations of their mathematical thinking. These gestures thus played an important part in the persons' interaction as complements to their utterances (cf. Goldin-Meadow, 2009; Ladel & Kortenkamp, 2013).These externalisations indicate that the children are participants in a process of appropriating the mathematical concepts of sorting and counting and thus the number concept.

Apparently, the digital tool carries both affordances and constraints (cf. David & Watson, 2008) with respect to the participants' collaboration, in particular within the context of using the screen and mouse to engage with the digital tool. The applications engaged with

offer several opportunities for interaction and action among the participants. The applications are about *doing* something with mathematical objects and toys, thus the affordances are related to counting and sorting squares and toys in accordance with given numerals. The children have to make sense of the screen in each case, with its inherent pictures, table, diagrams, and mathematical symbols. Moreover, the children have to interact with the digital tool in order to carry out the supposed actions. As argued above, the digital tool affords the children to become interested in the activity of moving and stacking coloured shapes on the screen and tapping falling toys. However, it is also evident that the digital tool, in the way it is operated in this study, has limitations with respect to actively engaging both children at the same time. This is also due to the difference in equipment used. The boys engaged with a portable computer with a mouse. The mediation of actions by way of the mouse constrains collaboration between the boys. In the girls' situation the touchable screen potentially affords collaboration even though this is not particularly taken advantage of. I thus argue that opportunities for mathematical learning were more afforded in the girls' situation than the boys' situation, since the touchable screen gave the girls more explicit possibilities for mathematical collaboration.

Dialogue is in both excerpts used as a medium of learning. The adults' comments, questions, and prompts made their interaction with the children and the digital tools into learning activities. In both excerpts, the adults took a dominant role, particularly in excerpt 1. This domination of the interaction may constrain both the interaction between the child and the digital tool as well as interaction amongst the children. Nevertheless, as more capable peers, the adults orchestrated the interaction with the digital tools and dealt with the tools' affordances and constraints (David & Watson, 2008). The affordances were taken advantage of to create opportunities for the children to appropriate the mathematical concepts implicitly present in the applications. The tools' constraints reflected a didactical dissonance from the outset (cf. Vangsnes et al., 2012). However, this dissonance was transformed into greater harmony due to the multimodal adult–child interaction (cf. Goldin-Meadow, 2009; Radford, 2003; Roth, 2001).

There is thus no striking didactical dissonance emerging in the two excerpts that we have seen. Rather, I argue that didactical *harmony* occurs in these situations. The adults take advantage of the digital tool's affordances in order to orchestrate mathematically meaningful learning activities on behalf of the children. These competent adults prolong the learning space of the digital tool. This result thus complements the argument of Vangsnes et al. (2012) in that didactical dissonance is possible to avoid when using digital tools designed to foster

mathematical learning. Moreover, prolonging the digital tool's learning space is possible when competent adults take advantage of the tool's affordances.

Even though this study is limited to the analyses of two situations, it is evident that the adults play crucial roles in orchestrating these situations as mathematical learning opportunities. In each setting, the adult carries out actions, asks relevant questions, and comments on the children's interaction with the tool(s). Through their questions and comments they seek to explicate the implicit mathematical concepts and ideas involved in the application(s). The digital tool's mathematical affordances are in the kindergarten context heavily and wholly dependent on the competent adult and his/her situational judgements, along with the children's interaction, the mathematical questions asked and mathematically clarifying comments made. More research is needed to further analyse the mathematical learning opportunities afforded when kindergarten children interact with digital tools.

This view of the process of appropriation is fruitful when studying children's engagement with digital tools, since the research conducted deals with children participating in activities where they are indirectly exposed to mathematical ideas and concepts through the use of digital tools. To be specific, the children studied here are in their initial phase of using mathematical and digital tools. In order to participate actively, meaningfully, and critically, they need to know how to interpret pictures, tables, and diagrams, know how to operate the mouse and a touchable screen, and they need to know how to interpret graphs and mathematical symbols used within the web-based applications.

References

Buckingham, D. (2006). Defining digital literacy – What do young people need to know about digital media? *Nordic Journal of Digital Literacy, 1*(4), 263–276.

Carlsen, M. (2010). Appropriating geometric series as a cultural tool: A study of student collaborative learning. *Educational Studies in Mathematics, 74(2)*, 95-116.

Cohen, L., Manion, L, & Morrison, K. (2011). *Research methods in education* (7th ed.). London : Routledge.

David, M. M., & Watson, A. (2008). Participating in what? Using situated cognition theory to illuminate differences in classroom practices. In A. Watson, & P. Winbourne (Eds.), *New directions for situated cognition in mathematics education* (pp. 31–57). Boston, MA: Springer.

Fischer, J.-P. (1992). Subitizing: The discontinuity after three. In J. Bideaud, C. Meljac, & J.-P. Fischer (Eds.), *Pathways to number. Children's developing numerical abilities* (pp. 191–208). Hillsdale, NJ.: Lawrence Erlbaum.

Goldin-Meadow, S. (2009). How gestures promotes learning throughout childhood. *Child Development Perspectives*, *3*(2), 106–111.

Goodwin, K. (2008). The impact of interactive multimedia on kindergarten students' representations of fractions. *Issues In Educational Research*, *18*(2), 103–117.

Guðmundsdóttir, G. B., & Hardersen, B. (2012). *Småbarns digitale univers. 0–6-åringers tilgang til og bruk av digitale enheter på fritiden* [Small children's digital universe. 0–6 year-olds' access to and use of digital units in their free time]. Oslo: Senter for IKT i utdanningen.

Hundeland, P. S., Erfjord, I., & Carlsen, M. (in press). Use of digital tools in mathematical learning activities in the kindergarten: Teachers' approaches. *Proceedings of the Eight Congress of the European Society for Research in Mathematics Education.*

Ladel, S., & Kortenkamp, U. (2013). An activity-theoretic approach to multi-touch tools in early mathematics learning. *International Journal of Technology in Mathematics Education, 20*(1), 3-8.

Lantz-Andersson, A., & Linderoth, J. (2011). The voice of absent designers. Students' strategies when solving mathematical problems using educational software. *Nordic Journal of Digital Literacy, 6*(1&2), 52–74.

Linell, P. (1998). *Approaching dialogue. Talk, interaction and contexts in dialogical perspectives*. Amsterdam: John Benjamins Publishing Company.

Ministry of Education and Research (2006a). *Rammeplan for barnehagens innhold og oppgaver* [Framework plan for the content and tasks of kindergartens]. Oslo: Ministry of Education and Research.

Ministry of Education and Research (2006b). *Temahefte om "IKT i barnehagen"* [Thematic booklet on "ICT in the kindergarten"]. Oslo: Ministry of Education and Research.

Moschkovich, J. N. (2004). Appropriating mathematical practices: A case study of learning to use and explore functions through interaction with a tutor. *Educational Studies in Mathematics*, 55, 49–80.

OECD (2006). *Starting strong II. Early childhood education and care*. Paris: OECD Publishing. Retrieved February 24, 2011, from http://www.oecd.org/dataoecd/14/32/37425999.pdf

Plowman, L. & Stephen, C. (2003). A 'benign addition'? Research on ICT and pre-school children. *Journal of Computer Assisted Learning*, *19*, 149–164.

Radford, L. (2002). The seen, the spoken and the written: A semiotic approach to the problem of objectification of mathematical knowledge. *For the Learning of Mathematics*, *22*(2), 14–23.

Radford, L. (2003). Gestures, speech, and the sprouting of signs: A semiotic-cultural approach to students' types of generalization. *Mathematical Thinking and Learning*, *5*(1), 37–70.

Rogoff, B. (1990). *Apprenticeship in thinking. Cognitive development in social context*. New York: Oxford University Press.

Rogoff, B. (1995). Observing sociocultural activity on three planes: Participatory appropriation, guided participation, and apprenticeship. In J. V. Wertsch, P. del Río, & A. Alvarez (Eds.), *Sociocultural studies of mind* (pp. 139–164). Cambridge, MA: Cambridge University Press.

Roth, W.-M. (2001). Gestures: Their role in teaching and learning. *Review of Educational Research, 71* (3), 365–392.

Säljö, R. (2001). *Læring i praksis. Et sosiokulturelt perspektiv* [Learning in practice. A sociocultural perspective]. Oslo: Cappelen Akademisk Forlag.

Säljö, R. (2005). *Lärande & kulturella redskap. Om lärprocesser och det kollektiva minnet* [Learning & cultural tools. On processes of learning and the collective memory]. Stockholm: Norstedts Akademiska Förlag.

Sarama, J. & Clements, D. H. (2004). Building blocks for early childhood mathematics. *Early Childhood Research Quarterly*, *19*, 181–189.

Vangsnes, V., Gram Økland, N. T., & Krumsvik, R. (2012). Computer games in pre-school settings: Didactical challenges when commercial educational computer games are implemented in kindergartens. *Computers & Education*, *58*, 1138–1148.

Vianna, E., & Stetsenko, A. (2006). Embracing history through transforming it: Contrasting Piagetian versus Vygotskian (activity) theories of learning and development to expand constructivism within a dialectical view of history. *Theory and Psychology*, *16*(1), 81–108.

Vygotsky, L. S. (1978). *Mind in society. The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1986). *Thought and language*. Cambridge, MA: The M.I.T. Press.

Wells, G. (1999). *Dialogic inquiry: Towards a sociocultural practice and theory of education*. Cambridge: Cambridge University Press.

Wertsch, J. V. (1998). *Mind as action*. New York: Oxford University Press.

---

[i] This project was funded by the programme LA2020 at the University of Agder. In this project I collaborated with two colleagues, Per Sigurd Hundeland and Ingvald Erfjord.

[ii] This article shares research issues with a Norwegian article: *Barns bruk av digitale verktøy i barnehagen: Muligheter for å gjøre seg matematiske erfaringer*., which will be published in the journal Nordic Studies in Mathematics Education. However, the Norwegian article has a different focus than what is the case here.

[iii] Transcription codes: (.) small break; (…) longer break; *italics* words associated with non-verbal activity; - sudden break; :: prolonged sound or letter; . end of sound; CAPS loud utterance.