Mentoring Prospective Mathematics Teachers as Conductors of Whole Class Dialogues – Using Video as a Tool

Introduction

> I have never in any field practice experienced such concrete and useful mentoring sessions. [Now] I have specific and relived issues to work on next time I have a similar dialogue.

This statement from Hannah[1] can be read in a reflective log she wrote as a student teacher during her field practice in her third year of the initial teacher education program for primary school in Norway. She has conducted a whole class dialogue in mathematics with a class of third graders and reflects on the outcome of the post-lesson mentoring session using videos from her teaching as a tool. In Hannah's opinion, the field practice has been more "useful" than what she experienced in the two previous years because this time the mentoring left her with "specific issues to work on" with a view to improving her future teaching. The mentoring was "concrete" and allowed her to "relive" some issues connected to the way she orchestrated the mathematical whole class dialogue.

The focus of Hannah's field practice is closely connected to current research that shows that mathematical reasoning is important for children's later achievement in mathematics (Nunes, Bryant, Sylva, & Barros, 2009). However, questions posed within mathematics classrooms across the world fail to provide pupils with opportunities to explore mathematical connections and to reason about mathematical concepts (Hiebert et al., 2003). Asking questions that probe pupils' reasoning is a complex skill that requires thoughtful planning, and analysis of the mathematical and pedagogical goal of the lesson (Manouchehri & Lapp, 2003). Prospective teachers pose questions quickly with few follow-ups, giving little time for the pupils to expand their answers (Henning & Lockhart, 2003). Thus, an important part of learning to teach mathematics is to develop questioning skills for mathematical understanding and reasoning.

Learning how to listen to and interpret pupils' mathematical ideas is not a simple task (Chamberlin, 2005). Author (1995) found that student teachers have difficulties responding to unexpected responses from pupils. Ball and Forzani (2009) argue that if there is an unknown factor when it comes to questions posed in classrooms, it is what pupils' responses will be. Novices need a tool that enables them to foresee what is coming. Engaging in mathematical

[1] All names are pseudonyms.

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conversations can provide the type of insight into pupils' thinking that is needed for teaching with understanding (Franke, Kazemi, & Battey, 2007). Practices of eliciting and responding to pupils' ideas, setting and maintaining expectations or leading particular types of discussions within different content areas, such as whole class conversations in mathematics, are examples of core practices in teacher education (Grossman, Hammerness, & McDonald, 2009; Lampert et al., 2013).

Due to the importance of learning environments that allow pupils to articulate their mathematical thinking and knowledge on core practices, we designed an intervention project where researchers from the teacher education at the x University are collaborating with a school-based mentor in a primary school. By studying Hannah and three of her fellow student teachers in their field practice with their two mentors, a lecturer in mathematics from the university and a primary teacher, our aim has been to explore how videos from the student teaching can influence and support the student teachers' learning of how to conduct mathematical dialogues with pupils. We argue for the relevance of our intervention project based on knowledge or lack of knowledge in three areas. We have already referred to research documenting the importance of teacher skills concerning how to conduct mathematical dialogues and documented difficulties student teachers show in this area. Below we will present studies that show there is only limited focus on subject-matter skills in mentoring conversations, and little research on mentoring using videos of student teaching in field practice. Investigating the outcome of the intervention our research question is, *what was the nature of the post-lesson mentoring using video as a tool?* To answer our question, we analysed videos of mentoring when looking at student teaching. The findings are presented through an illustrative example from the mentoring focusing on Hannah's student teaching.

Research on mentoring conversations and video as a tool in teacher education

A preoccupation with immediate issues of practical performance rather than inquiry into the rationale for the performance is found to be the main focus among mentor teachers (Edwards; 1995; Franke & Dahlgren, 1996; Wang & Odell, 2002). This has later been sustained, teaching strategies, instructional and organizational competence are identified as dominating topics in mentoring conversations. Strong and Baron (2004) found that 70 % of mentors' suggestions to novice teachers were focused on teaching as instructional matters and classroom management, 18 % were related to pupils, while only 2 % of the suggestions were related to subject matter. Much of the advice given by two mentors in science teaching

concentrates on general pedagogical knowledge (mainly organization and class management), while the domain of subject-matter knowledge was almost absent in the conversations (Bradbury & Koballa, 2007). In the Norwegian context, mentoring conversations in field practice tend to be emotional support focusing more on classroom management and less on subject matter (Helgevold, Næsheim-Bjørkvik, & Østrem, 2015; Jensen, 2016; Ohnstad & Munthe, 2010). As reported by Valencia, Martin, Place and Grossman (2009), the few visits from university lecturers do not seem to change this focus, neither does the use of tools like log writing (Author, 2013). One intervention study (Author, 2016a; Author, 2016b), however, documented increased professional orientation when lecturers from the university over time took part in the dialogue together with the student teachers and their school-based mentor on a digital platform. Blogging and writing in discussion forums prompted the student teachers to include theory and professional terminology when reflecting on their own and their fellow student teachers' teaching. Correspondingly the mentor's local and experience-based knowledge on teaching and pupils' learning became visible. This small-scale study shows the potential in such scaffolded reflective writing and close collaboration between lecturers and mentors. A Lesson Study approach to field practice is another promising initiative in the Norwegian context stimulating the student teachers to make enquiries into the core issues of teaching (Helgevold et al., 2015).

Nonetheless, more intervention studies are required to ensure the development of high-quality field practice focused on core practices, such as whole class dialogues in mathematics. Internationally, a number of studies have used video in preservice teacher education (Brouwer, 2011; Gaudin & Chaliès, 2015). A great proportion of these focus on observing professional teaching. There are also a number of studies where preservice teachers view videos of their own teaching, either peer teaching or video clips of student teaching during field placement. However, we find that the discussions around these videos mainly take place in courses at the university. Mathisen and Bjørndal (2016) report on a study using video as a tool in mentoring preservice teachers in field practice. Using tablets as an observing eye in field practice, the student teachers became more active observers and were better prepared for supervision. They also developed a culture of sharing (notes, taped situations) and giving honest responses, important aspects in group tutorials. Our study, however, differs substantially from this study as we use video to focus on student teachers conducting whole class dialogues, a core practice in mathematics teaching.

Blomberg, Renkl, Sherin, Borko and Seidel (2013) argue that teachers find it more meaningful to analyse their own teaching than that of others. Sherin (2004) and Coles (2013)

demonstrate that such video-viewing fosters the teachers' capacity to direct their attention on pupils' thinking and learning. Using video, teachers tend to talk in a more focused, in-depth and analytical manner about specific issues related to teaching and learning (Borko, Jacobs, Eiteljorg, & Pittman, 2008; Coles, 2013).

The findings by Rosaen, Lundeberg, Cooper, Fritzen and Terpstra (2008) suggest that there is a change in the quality of the reflections made by interns when supported by video of their own teaching:

> [Video-supported reflection] shift[s] the content of their reflections from a focus on classroom management in memory-based reflections to a focus on instruction when video was available, focus less on themselves and more on children when they reflected on video clips of their teaching (p. 347).

Video-viewing in this way seems to help novice teachers examine their ability to facilitate discussions by slowing down the fast pace of classroom life so that different aspects of the classroom dialogue can be analysed.

Building on these experiences from experienced teachers' and interns' learning we follow Seidel, Stürmer, Blomberg, Kobarg and Schwindt (2011), who conclude that it makes sense to start professional development activities by working with videos of one's own teaching, and Masats and Dooley (2011), who assert that video coaching can play an important role in field practice. Our study investigates how such use of video can support the student teachers' learning at an early stage, still attending courses at the university. This is the background for our intervention. In the next section we present the context and the focus of our intervention study which was conducted in the 2015-2016 academic year.

The intervention study – theory, setting and participants

Building upon a socio-cultural framework, we understand mentoring as a mediated activity (Moll, 2001; Vygotsky, 1987). Two features of sociocultural theory are especially relevant for our intervention. First, the claim that higher mental functioning in the individual, such as reasoning and problem solving, derives from social life. Second, the idea that higher mental functioning and human action in general are mediated by tools and signs. Vygotsky sees mediation as providing the bridge that connects the external with the internal and thus the social with the individual (Wertsch & Stone, 1985). Individuals use tools to mediate their thinking and to collaborate. Vygotsky found language to be the most important mental tool and the basis for the dialogic classroom. In our intervention videos from student teaching sessions are a key mediating tool in the post-lesson mentoring.

At the time of the intervention study Norwegian teacher education for primary school was a four-year integrated program. Each year the student teachers had on average six weeks of field practice in groups of four and parallel studies in education and diverse subject matter. Official documents (Ministry of Education and Research, 2009) state that field practice and theoretical studies are equal arenas for learning in teacher education. Mentors in contracted schools have the main responsibility for mentoring during field practice and are regarded as teacher educators. The student teachers are mentored before and after they are teaching, hereafter called pre- and post-lesson mentoring. The mentor in this study, hereafter "the primary mentor" (PM), is an especially well-educated primary-school teacher with a master's degree in mathematics didactics. At the time of the study, she attended a course qualifying as a mentor.

In addition to the school-based mentor, Norwegian student teachers have a designated lecturer from the university following up during field practice (hereafter UM). The role of the UM varies, but normally she visits the student teachers' field practice twice a year. UMs often place themselves in the back row when visiting, but as part of the intervention, the UM played a significant role in the pre- and the post-lesson mentoring. Two lecturers served as UMs throughout the study year as one of them was on maternity leave.

The participating student teachers Ann, Hannah, Laura and Mary, all in their early twenties, were voluntarily recruited while in their third year of their studies. During field practice the student teachers are to teach almost all the PM's lessons, individually or in pairs, while the rest of the group are observing. We intervened in the planning and the mentoring of four of these lessons, one mathematics lesson for each student teacher. Hannah and Ann's lessons took place in the autumn semester, Laura and Mary's lessons were in the spring semester. The student teachers, the PM and the UM took part in all four pre- and post-lesson mentoring sessions.

The four student teachers are attending a teacher education program with special emphasis on science and mathematics. Mathematics dialogues with pupils are a substantial part of the program and are a focus point in both the course literature and seminars based on videos of professional teaching. The student teachers together with their two mentors planned for *productive mathematical whole class dialogues,* as defined by Sfard & Kieran's (2001):

> The term productivity (...) refers to discourse which can be proved to have some concrete lasting effect: the discourse has led to the solution of a problem, it influenced participants' thinking and ways of communication, it changed their mutual positioning, it became richer in rules and concepts. In the case of

> mathematics discourse, an interaction will be regarded as educationally productive if it is likely to have durable and desirable impact on students' future participation in this kind of discourse (p. 50).

Sfard and Kieran see effective communication between partners as a prerequisite for the productivity of a mathematical discourse. The communication is effective when "the different utterances of the interlocutors evoke responses that are in tune with the speakers' meta-discursive expectations" (Sfard & Kieran, 2001, p. 49). Transferred to student teaching, the student teacher must be able to understand each pupil's utterances and tune her responses to fit with the pupil's understanding. But if the whole class dialogue is to be defined as productive, the communication between the student teacher and *all* the pupils involved must be effective. Thus, the student teacher must be able to present the speaking pupil's idea in a form which also meets the listening pupils' expectations. In addition to understand the pupils' utterances, the able conductor of a whole class dialogue translates the utterances of pupils to the other pupils and sequences the pupils' participation in a way that makes sense for all.

The term *revoicing* corresponds to this idea of interpreting and translating the pupils' utterances. As deep thinking and powerful reasoning do not always correlate due to a lack of precise terms, the teacher must revoice, or reutter a pupil's contribution by repeating, rephrasing, elaborating or translating the meaning. Revoicing is one of several recommended talk moves in mathematical discussions (Chapin, O'Connor, & Anderson, 2009) often used by mathematics teachers as a means of apprenticing pupils in the use of precise language. In revoicing it is essential that the teacher's utterance is true to the pupil's idea and a verbal or written representation of the original idea. Duval (2006) proposes that multiple written representations should be used to scaffold learning processes in mathematics.

Prior to our intervention, the student teachers have twice experienced their own teaching through audio-recordings. However, this is the first time the student teachers are being filmed and, as Hannah phrases it in the introduction, can "relive" their teaching and work on it with their mentors. During student teaching, one permanent video-camera was placed in the back of the classroom focusing on the smartboard and the teacher. The video material used in the mentoring sessions was not edited in any way but consists of "raw" data from the student teaching.

The two mentors and all four student teachers were asked to stop the video from the classroom dialogue whenever they saw something they wanted to discuss. In two cases, the UM viewed the video beforehand. In all cases both mentors prepared for the mentoring by reading reflective logs written by the student teachers. Blomberg et al. (2013) assert that there

is a need to focus novice teachers' attention when they observe video. Hence, the mentors played an important role in facilitating the dialogue.

To summarize, due to what we know about the importance of the classroom dialogue for pupils' learning of mathematics and about novices' problems orchestrating such dialogues, we wanted to facilitate such activities as part of the student teachers' field practice. Our aim was to strengthen the mentoring regarding how to orchestrate whole class dialogues in mathematics with a focus on pupils' learning. To achieve this UM played an active role together with PM using video of the student teachers' own teaching as a tool.

The research study

To investigate the outcome of the presented intervention study we asked the following research question, *what was the nature of the post-lesson mentoring using video as a tool?* As video makes it possible to freeze, capture and recapture situations in detail, a video-based design encompasses the complexity and diversity of voices, perspectives and issues at play during teaching and learning in classrooms (Klette, 2009). The same comes into play in mentoring. Moreover, in studies of language and communication, details and correct accounts are of great importance, including both verbal and non-verbal expressions. Thus, in addition to the videos of the student teaching, both the pre- and the post-lesson mentoring were video-recorded for research purposes. In the mentoring sessions one permanent video-camera was placed facing the conference table and the video-screen showing the student teaching.

Data material and analysis

The data sources used to answer the research question are videotapes and transcripts of these tapes from four post-lesson mentoring conversations. The mentoring sessions differ in length; 46, 52, 54 and 59 minutes.

The first step in our analysis was to partition the mentoring sessions into sequences in accordance with how the video from the student teaching was viewed, a new sequence each time the video was stopped. Consequently, each sequence includes the video clip from the classroom that has been viewed and the mentoring of this video clip. We also noted who initiated the stop. Although all participants were invited to stop the video whenever they wanted to discuss an issue, the mentors most often took this role (31 out of 37 times).

Then, going between the different video clips in each sequence we identified the thematic focus in both the whole class dialogue and the corresponding discussion in the mentoring session. The results from this thematic analysis have been registered in four tables, one for each student teacher. Table 1 shows how the mentoring conversation unfolded based on the video from Hannah's student teaching (tables from all four mentoring conversations can be found in the Appendix).

Table 1: Thematic focus in the mentoring based on video clips from Hannah's whole class dialogue (autumn).

Jacob, Lamb og	Duration of the video sequences discussed	Focus in the video clip from the classroom	Duration of the discussion connected to the single video clip	Who stopped the video	Topic discussed in the mentoring conversation
1	1 min 10 sec	Teacher's presentation of an addition task	1 min 27 sec	PM	Classroom management, creating an environment with time to think
2	1 min 10 sec	Pupil presenting her idea and the teacher repeating it	8 min 26 sec	UM	Interpreting pupil's ideas and choice of **representations**
3	2 min 1 sec	Interpreting one pupil's idea through dialogue with her, another pupil and the class, writing down the task and pointing at the board	4 min 41 sec	UM	Interpreting pupil's ideas and choice of **representations**
4	1 min 17 sec	Pupils thinking on a task, then sharing their ideas in peer-groups	2 min 7 sec	UM	The need to monitor the pupils' talk while they are working
5	2 min 2 sec	Whole class dialogue about different calculation strategies including verbal interpretation of two pupils' joint idea	3 min 11 sec	UM	Ways of **representing** the pupil's idea on the board
6	2 min 10 sec	Pupils thinking on a task, then sharing their ideas in peer groups	2 min 35 sec	Han nah	Student teacher explaining that she monitored a peer group to be able to use their idea in the whole class dialogue
7	2 min 15 sec	Pupil presenting his idea and the teacher interpreting it and pointing at the different tasks on the board	7 min 19 sec	UM	Choice of **representations** Representing pupils' ideas in whole class dialogues and ways of including the other pupils
8	2 min 21 sec	Two pupils presenting each their ideas, the teacher interpreting them orally and writing on the board	2 min 5 sec	UM	Interpreting the pupils' ideas and choice of **representations**
9	2 min 25 sec	Interpreting a pupil's idea orally with support from different pupils	10 min 42 sec	PM	Limits regarding use of pupils' ideas in whole class dialogues The need for efficiency improvements through foreseeing and choice of examples and ways of **representing**
Hannah – whole class dialogue: 33 min/mentoring session: 59 min					

The thematic analysis shows that the task of representation stands out as the dominating topic in the mentoring conversations. This is illustrated in Table 1 which shows that six out of nine sequences in the mentoring regarding Hanna's teaching were about representation. The

corresponding numbers from the other mentoring sessions are three out of five, eight out of nine and six out of fourteen (see the appendix).

To answer our research question and find the nature of the mentoring, the next step in our analysis then was to delve deeper into the task of representation and how the mentoring related to this. Going into each of the 23 mentoring sequences regarding representation and the corresponding student teaching, we have conducted an inductive qualitative analysis using procedures and techniques from the constant comparative method (Strauss & Corbin, 1998), with comparisons and questions being the most important tools. Guided by the finding from the first analysis, we used Strauss' and Corbin's flip-flop technique, where the concept 'representation' was turned inside out and up-side down. Digging into the concept of representation we asked: what aspects of representation were in focus in each of the mentoring sequences and how did the discussion relate to the video clips from the student teaching? Who suggested the different representations that were in focus in the mentoring? To what extent was the problem of representation related to the individual pupil's idea and to what extent was it related to the pupils as a group? Relating to the classroom dialogues we asked: how are the pupils' utterances understood and represented? The findings in this inductive analysis are that the student teachers found it difficult to understand the pupils' ideas, to develop written representations that matched the pupils' ideas and to present suitable representations on the board that gained all the pupils' learning.

A framework of noticing

As inductive researchers we searched for theories that could explain or interpret our findings (Goetz & LeCompte, 1984). Theory gives meaning to qualitative data and are used as a tool for insight. The choice of theory depends on what the data tells you: "Although most researchers align themselves with a special theoretical framework, it is standard to borrow from diverse frameworks to make sense of data" (Taylor & Bogdan, 1998, p. 148).

Jacob, Lamb og Philipp (2010, pp. 172-173) define and conceptualize the construct 'professional noticing of children's mathematical thinking' as a set of three interrelated skills. We found this concept suitable as a framework to analyse the nature of the mentoring conversation and to further understand our findings. The first of the three interrelated skills is *attending to children's strategies* which entails to attend to the mathematical details in children's strategies. Jacobs et al. (2010) argue that these details serve as the teacher's "windows into children's understanding". *Interpreting children's mathematical understandings,* the second interrelated skill, is concerned with how the teacher "interprets children's understandings as reflected in their strategies" and if this is "consistent with both

details of the specific child's strategy and the research on children's mathematical development". The third and last skill, *deciding how to respond on the basis of children's understandings,* is the reasoning the teacher use when deciding on an intended response. To what extent do the teacher use what she has learned about the children's understanding? The professional noticing of children's mathematical understanding is described as an "in-the-moment decision-making" expertise (p. 169) that it is both challenging and complex.

Credibility and ethics

All three researchers in this study have multiple roles which might affect the research. All three took part in the planning of the intervention project. In addition, one of the researchers served as the UM in the spring semester, and the other two taught in the mentoring course PM was attending at the time. Thus, it was important to be constantly aware of how these relationships might colour our analysis and interpretation. We are aware of the pitfalls in "studying ourselves" and strived to monitor our different subjective I's (Peshkin, 1988). To balance our double roles as educators and researchers, each researcher analysed on their own and then compared their findings to reach a common understanding. According to Lincoln and Guba (1985), dependability concerns whether the findings make sense given the collected data, and not whether the findings can be repeated. To give the readers insight and show that the findings are credible and consistent with the data collected we have chosen to illustrate our findings showing the analysis and interpretation of one whole sequence. Accompanying the tables with a rich selection of quotations and examples we aim to support the transferability and the dependability of the study. The last procedure was member checking with the PM and the UM.

We have followed the guidelines of the National Committee for Research Ethics in the Social Sciences and the Humanities (NESH) in Norway, with written consent collected from the school, all the parents of the pupils involved and all the student teachers. In all of the examples, pseudonyms are used. The project plan has been approved by the Norwegian Centre for Research Data (NSD).

Findings

We have chosen to illustrate our findings by focusing on Hannah's lesson. The reason for choosing this lesson is that the mathematics involved is relatively simple, allowing us to reach a wider audience, including non-mathematicians. The reason for choosing sequence two, Hannah's dialogue with Sarah (see Table 1), is that this representative sequence comes early

in the mentoring conversation. If choosing a later sequence, we would have needed to explain references to earlier parts of the conversation.

The post-lesson mentoring conversations were part of a greater whole, including pre-lesson mentoring conversations, student teaching and communication through log writing. The student teachers wrote daily reflective logs during the entire field practice, and both the PM and the UM gave written responses. To support the reader's understanding of our findings regarding the mentoring sessions, we start this section with a description of the teaching sequence discussed in sequence two in the mentoring and the corresponding reflective logs written before the mentoring. This is necessary contextual information.

Conducting a whole class dialogue

Hannah's dialogue with Sarah is part of a longer whole class dialogue on addition. The excerpt[2] starts with Hannah introducing the task 36+40, underlining that she wants the pupils to focus on "a way to solve the problem":

C3. H: Now I'm going to write a task on the board. I want you to think on your own and when you have found a way to solve the problem, show me with a "thumbs up" (...)

C4. H: Thirty-six plus forty (writes 36+40 on the smart board). Now I'll give you time to think. (quiet for 30 seconds)

C5. H: I see many of you have found a way already, but I'll wait a little longer and see if some more of you find a way to solve this mathematical task. Give me a sign when you're ready. (quiet for 25 seconds)

C6. H: Sarah, would you like to tell us what you found out?

C7. S: Eh.... That it makes seventy-six.

C8. H: That it makes seventy-six. Tell me how you figured that out. How did you make seventy-six out of these numbers?

C9. S: Because I added together the tens first and then I added the ones.

C10. H: So, you added the tens first. How many tens do we have in this task? (Points at 3 in 36).

C11. S: Seventy, I mean seven.

C12. H: What did you say?

C13. S: Or three.

C14. H: Three tens. And here? (Points at 4 in 40)

C15. S: Four.

C16. H: Four tens (writes =). And then you found that it makes....?

C17. S: Seventy.

[2] The utterances in the classroom dialogue are labelled with a C.

C18. H: Seventy (writes 7 on the board). And where did you get the number six?

C19. S: From thirty-six.

C20. H: From thirty-six, so, from this number? (Points at 36)

C21. S: Yes. (Hannah writes 6 behind 7 on the board)

The dialogue on 36+40 lasts for approximately five minutes including Hannah's introduction and almost one minute of thinking time. All Hannah writes on the board is 36+40 = 76. How Sarah operated when she added the numbers is not represented.

Immediate reflections after Hannah's teaching

In the evening, Hannah writes in her log:

> I often wondered if the other pupils understood what was said, or if the pupil who was speaking was the only one who understood her own idea. (…) I should have written down the [different] ideas on the board in a clarifying manner so the pupils could have had something concrete to compare.

The possibility that the pupil who is speaking might be the only one who understood the presented idea is highlighted in PM's response later in the evening and this is an observation she wants to spend time on in the mentoring session. She adds: "This goes together with your point concerning how to use the board. How can the board contribute to the clarification of the pupils' ideas?"

The problems interpreting and representing the pupils' ideas on a level adapted to all pupils are described in all the student teachers' logs. Laura expresses this as follows: "It's unfortunate for the pupils if [the teacher] misunderstand their explanations or doesn't realize that they actually try very hard to express what they think." Commenting on the logs the PM reminds the student teachers of the issues raised in the pre-lesson mentoring sessions. Issues like how to represent the pupils' strategies, what could be a good notation on the board for specific strategies and how to choose between and display the pupils' different strategies were all discussed during the joint planning session.

To summarize, the student teachers and PM had a joint understanding of the need to focus on how to represent the pupils' thoughts in a productive way before they joined the video session. Viewing the video and reading the logs, UM was also well informed. The question then is: how does the use of video add to the mentoring conversation beyond this level of awareness of the importance of such representations and of the personal lack of relevant skills? We will move on to the findings of our analysis of the mentoring

conversations. The findings are illustrated by the analysis of the mentoring session focused on the video from Hannah's student teaching.

Analysis of the post-lesson mentoring session

Sequence 2, see Table 1, starts with one minute and ten seconds of video-viewing (C4-C8) before the student teachers and the mentors have an eight-and-a-half-minute-long discussion (M15-M53[3]) on Hannah's problems interpreting and representing Sarah's idea. We start our analysis by entering the discussion when UM stops the video as Sarah says, "because I added together the tens first and then I added the ones" (C9):

M15. UM: Do you hear what Sarah explains? Added the tens first and then added the ones, is that what she says? (Confirming nods around the table.)

M16. UM: Now, if we think about PM's concern, how can we ensure that the other pupils also get the strategies – and how can we help them, so they don't fall off? (...)[4]

M17. UM: Have you figured out anything later on? You might not remember all the suggestions you made in your log. What would you like to use? Write down more of the things the children say? Now when you hear what Sarah says, how could you, Hannah, or anyone of you, how could we possibly have represented what Sarah says? Added the tens first and then the ones.

By pointing to and repeating Sarah's exact words twice (M15, M17) and asking the student teachers to confirm what she heard, UM addresses the importance of *attending to the pupil's strategies*. We recognize the first of the three interrelated skills in *noticing* (Jacobs et al., 2010). Our interpretation is that UM wants the student teachers to listen to and make a joint interpretation of Sarah's idea as a starting point for the continuing dialogue, and she uses the video as a tool for getting it right.

Deciding how to respond on the basis of children's understanding is the third of the interrelated noticing skills (Jacobs et al., 2010). In M15-M17, the UM apparently tries to scaffold the student teachers' learning of response skills based on the situation in the video-clip. The student teachers, supported by the mentors, try to provide a correct interpretation of Sarah's idea which is understandable to the other pupils and could have helped Hannah keep all the pupils involved in the dialogue. Helping the student teachers to decide, UM in M17

[3] The utterances in the mentoring dialogue are labelled with an M. The utterances are numbered consecutively as they took place in the mentoring session.

[4] Some utterances have been abbreviated to exclude irrelevant or inaudible parts. This is indicated by (...).

points to the need for written representations and asks them to elaborate on suggestions they had made already in their logs after Hannah's teaching.

After setting the agenda as we just saw above, the mentoring sequence is all about how to interpret and represent Sarah's idea. UM first challenges Hannah on how to represent the idea "adding the tens and the ones". The dialogue continues:

M18. H: I could at least have looked into how many tens there are. But I'm not fully informed about their previous knowledge. I don't know if it's too trivial that there are three tens in thirty-six, or if it's a little difficult for them? If it's a little bit difficult, one possibility could be to look at how many tens there are in each number and how many ones there are in each number, and then write that down as a new arithmetic problem.

M19. UM: How do you think that arithmetic problem would look like?

M20. UM: In words or? How do we represent three tens in writing? Add the tens? There are several ways to consider, is it possible for example to write three tens plus four tens in words? The tens. Or we can write thirty plus forty, then it's numbers, but maybe not so many tens. Then you at least should *say* that this is three tens and this is four tens.

Hanna accepts UM's statement in M17 when she takes the need for a written representation as her point of departure in the search for a solution. Her idea is to explore how many tens and ones there are in each number and to "write that down as a new arithmetic problem" (M18). She continues:

M21. H: It's possible to use a number line. Like we talked about? But then I would have to start with one of the numbers, and that's not quite what she did. Because she pulled out the tens from the numbers, - *that* would have fully supported what she said.

Hannah's first proposal, to use the number line as a tool representing Sarah's mathematical idea (M21), refers back to the pre-lesson mentoring conversation. The student teachers' initial idea was to create a task that would direct the pupils towards the strategy "to jump with tens". Related to this strategy, the student teachers found the number line to be a relevant representation. What we find interesting, however, is the reason Hannah gives for rejecting the number line: "that's not quite what she did". When the number line does not fit, she once again attends to Sarah's idea and realizes that "adding the tens and the ones" is an insufficient description of Sarah's operation because before adding the tens and the ones Sarah had "pulled out the tens from the numbers". Her search for a suitable representation is thereafter based on the interpretation "to pull out the tens from the numbers":

M22. H: Maybe it even could have been possible to illustrate it as Base-ten?[5] [The pupils] sit so close together, so even if it's very small, everyone would be able to see it. To see how many tens there are in thirty-six, and how many there are in forty. OK, how many [tens] do we have in all? And how many ones are there?

M23. UM: We could have split the thirty-six into three tens and six ones, thirty and six.

M26. H: Still there wouldn't be any more on the board.

M27. UM: No, but you are demonstrating it.

M28. H: Yes, something they are familiar with.

M29. PM: And that I think is important for those who might not follow what you are saying.

M35. H: But how could I have written that without too much scribbling?

Sequence M22-M35 is about Hannah's second suggestion, to demonstrate Sarah's idea using concretes. Reflecting aloud, Hannah also rejects the concretes as a fully suitable representation because "still there wouldn't be any more on the board". She realizes that written representations of the different tasks and ideas on the board may have scaffolded the pupils' learning. This is the idea she holds on to in the mentoring conversation and asks for help to implement: "how could I have written that without too much scribbling?" (M35).

Before we continue focusing on their search for a written representation, we will make another point concerning the excerpt. Even if Hannah in the teaching situation was unable to find sufficient written representations, we find that utterances M18, M22 and M28 illustrate that she clearly understands the challenge of finding a way to respond based on both Sarah's and the other pupils' understanding. *Interpretation* is the second of the three noticing skills (Jacobs et al., 2010). To be able to have a dialogue with pupils in a productive way the teacher needs to understand the mathematical thinking that lies behind the pupils' utterances. Sarah's idea "adding the tens and the ones" in our example proves to be easy to interpret. But even if she understands that Sarah understands place-value, she is not sure that this is trivial to the rest of the pupils (M18). Hannah's concern for the pupils' previous knowledge and familiarity with the concretes shows that the search for an adequate way to represent Sarah's idea lives alongside with her caring for the group's understanding.

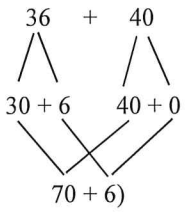
In utterance M23, UM describes Sarah's idea as a process of "splitting the tens and the ones", an idea Hannah follows up with no further comment. Encouraged by UM, the whole group gets involved in the dialogue, focusing on illustrating the splitting process as part of the teacher's response:

[5] Base-Ten: concretes representing the base-ten number system.

M37. M: I wrote like this now (shows that she has written 10+10+10+10+10+10+10+6 in her book). Because we said tens. (...) But I don't know if the zero should be written down here as well?

M39. A: It is possible, if you use concretes and say clearly that three tens is the same as thirty and four tens is the same as forty, then you might possibly write equals thirty plus forty plus six. If so, they will see very clearly that she says three tens and that equals thirty. However, without concretes that might [still] be vague to them?

M40. UM: I think that the splitting into three tens and six ones is important here. (...) Some notations you can use split the numbers with vertical markings (showing the others around the table that this could be written as



M41. H: Oh, yes!

M43. PM: Then I would, as Ann said, have added equals thirty plus forty plus six [on the board]. Then perhaps you could remove this (holds her hand over 30+6, 40+0, 70+6 and the vertical lines). Afterwards, wipe it out, and only leave this (points to 36+40=30+40+6) which shows what we have done. Because the splitting is important for those who don't have full control.

The excerpt illustrates how not only the nature of the different noticing skills (Jacobs et al., 2010) but also the learning of such skills is intertwined. By discussing how to respond using a written representation, they elaborate on their understanding of Sarah's idea. The idea of splitting the numbers is introduced by Hannah already in utterance M21 when she interprets Sarah's idea as pulling out the tens from the numbers. In utterance M37, Mary suggests writing 10+10+10+10+10+10+10+6 to focus on these tens, before Ann in M39 argues that they could write =30+40+6 because that clarifies "that she says three tens and that equals thirty". Mary's suggestion removes the focus on 36 as three tens and six ones. Thus, we see UM's support to Ann's suggestion (M40) and PM's follow up (M43) as the final breakthrough helping the student teachers to understand what is important in Sarah's splitting strategy. Mary's question about representing the zero ones in 40 is relevant in this strategy but was never discussed. "Oh, yes!" (M41), the interpretation of Sarah's idea and the written representation come together and seem to fit Hannah's search for how she could respond.

The student teachers' experiences with the video as a tool in mentoring

To complete the picture of our intervention we include a short presentation of the student teachers' own reflections on video as a tool in mentoring whole class dialogues (Author, in progress). In their logs written the evening after the post-mentoring session the student teachers highly value the video as a recall tool and a tool for common reference. Laura writes:

> I think it is beneficial for everyone involved to watch the video because it allows us to see exactly the same thing at the same time, thus knowing that we are talking about the same and that what we are talking about actually happened like that. We don't have to imagine erroneous things.

Hannah makes the same point, since "our memory often fails" the video helped them discussing "what really went on". Recalling the details, the video made it possible to discuss alternative choices of representation and possible solutions for how to conduct a productive mathematical discussion with pupils. Hannah writes:

> In that way [PM] could stop at any chosen point in the dialogue and guide us on concrete moves. I experienced that I gained a lot from dwelling upon the pupils' explanations. (…) When we watched the film in retrospect we could listen to the pupils' words over again and consider which representations were appropriate in the situation.

In Ann's words, the video enabled the student teachers and the mentors "to look into actual situations in a concrete way" from "a common point of departure" and this made it "easier to reflect". Even if it will take time to develop the skills she will need as a professional teacher, Ann feels that hard work in the project has brought her a step forward. She writes:

> Viewing the video, I have learned a lot. I think that every time you carry out a project like this you will be a little bit better prepared to meet the challenges. This is not something you will learn in one day; it is something you must put a lot of effort into.

The student teachers also focus on how the video enhanced the learning potential in the group as a community of learning. To Mary it became "nearly irrelevant" who was conducting the mathematical dialogue, in the video-based mentoring "the joint planning and reflection were the most important." To Laura the video brought the mentoring conversation to a higher level giving them as a group a common reference which enable them "to learn more from each other and to empower each other through discussion." Using video as a tool in the mentoring, Hannah anticipated that the focus would be on her insufficient performance. What she

experienced was that the focus was on "the pupils' thoughts and how [she] chose to handle them". We end the presentation of the student teachers' experiences with a supporting statement from PM posted in Hannah's log:

> I see the more specific focus on the pupils' learning and understanding as a great benefit from using video – in contrast to being caught up in all the other things around us which we also sense and think about during teaching.

The statement underlines what is prominent not only in Hannah's log but in all the student teachers' logs, video used in this way keeps the focus on pupils' learning, which in this project was the learning of mathematics.

Discussion

Our research question was, *what was the nature of the post-lesson mentoring using video as a tool?* We found *noticing* (Jacobs et al., 2010), to be a productive analytical tool capturing the nature of the post-lesson mentoring very well. Our findings show that all three aspects of noticing, *attending* to children's strategies, *interpreting* children's mathematical understandings and *deciding how to respond* on the basis of children's understanding, are key issues worked on in the mentoring sessions. The first and the last aspects are most prominent in all the mentoring sessions. In our illustrative example, attending to the children's strategy is in focus in the whole dialogue on how to represent Sarah's strategy. It starts with the UM's encouragement "Do you hear what Sarah explains?" (M15) and ends in M21 when Hannah concludes that Sarah's strategy is "to pull out the tens from the numbers". The last aspect, deciding how to respond, is in focus several times during the dialogue before they in M40 and M43 find a suitable way to represent the splitting strategy on the board. Even if the first and the last aspects of noticing are dominating the mentoring, there are also some examples of interpreting children's mathematical understanding. This is e.g. the issue when Hannah in M18 asks whether she can be certain that all the pupils know the place-value number system.

Bearing this in mind, the mentoring around noticing skills is not focused on a single pupil's understanding but relates to the whole group of pupils according to the definition of productive whole class discussions. To be "effective", the dialogue must fit all the pupils' understandings (Sfard & Kieran, 2001). That is the point of departure in the mentoring conversations striving to find suitable representations of Sarah's strategy. The focus on the pupils as a group stands out e.g. in M18, M22, M28, M29 and M39. Since discussing the choice of representations was prominent in all the mentoring sessions (Appendix), the

mentors follow Duval (2006) in underlining the use of written representations as necessary for understanding mathematical content.

Current research on the importance of building on pupils' own understandings in learning mathematics (Nunes et al., 2009) and on the complexity of the skills needed to create meaningful environments where pupils can reason (Chamberlin, 2005; Hiebert et al., 2003; Manouchehri & Lapp, 2003) document the need to train dialogue-skills in teacher education. The fact that choosing the right representations was the prominent theme in both semesters (see Table 1-4 in Appendix), indicates the need to repeatedly work on noticing skills over a long period of time in teacher education. When the mathematical theme and the context changed, the student teachers in our study once again experienced that they failed to foresee the pupils' answers and struggle to create written representations in-the-moment. It is not only a question of being aware of the need for noticing skills as certain qualities in the classroom dialogue, they needed more training in noticing. As expressed by Ann in her log, they were prepared to put much effort into training of orchestrating whole class dialogues over a long period of time. Jacobs, Lamb, Philipp and Schappelle (2011) claim to document that, given time, professional noticing of children's mathematical thinking can be learned. They also found that noticing skills are something teachers can acquire with support from videos which remove much of the complexity of classrooms.

As recommended by Franke et al. (2007) engaging in mathematical conversations can provide the type of insight into pupils' thinking that is needed for teaching with understanding. We argue that the best place to do so is in field practice in initial teacher education. In-the-moment decision-making is complicated as documented by Author (1995). However, by going back and freezing the situation on video, the students and their mentors were able to dwell on the pupils' explanations and discuss what possible choices could be made in interpreting and representing the ideas. Grossman et al. (2009) identified *decomposition* of practice, "breaking down complex practice into its constituent parts for the purpose of teaching and learning" (p. 2069) as one of three key concepts for understanding the pedagogies of practice in professional education. We argue that our analysis shows that by using the video as a tool, the mentors decomposed the practice according to the three interrelated skills in 'noticing' (Jacobs et al., 2010). Decomposing the complexity, concentrating on one skill at a time, the mentors made the situation accessible for learning. As reported by the student teachers in their logs, they were able to enter into concrete discussions on alternative choices regarding how the pupils' different utterances could be represented in a whole class dialogue.

We claim that, unlike in Valencia et al.'s study (2009), the university and the primary school mentors in our study proved to be a productive team scaffolding student teachers' learning. Based on video-clips from Hannah's teaching UM played a crucial role in the mentoring conversation. She sets the agenda for the mentoring in M15-M17 focusing on Sarah's strategy and how to represent it on the board. She then makes sure throughout the mentoring that the focus remains on finding a suitable written representation (M19, M23, M43). PM plays an important role keeping the focus on the needs of the class as a whole, first referred to by UM in M16 and later uttered by PM herself in M29 and M43. In the breakthrough (M40-M43) UM and PM collaborate on combining the different suggestions on how to represent Sarah's splitting strategy in a way they anticipate will fit all pupils. By decomposing the complexity of mathematics teaching into specific activities, they demonstrated that it was feasible to directly address representation which according to Deval (2006) is a key practice in teaching mathematics.

With reference to research our aim was to strengthen the mentoring regarding subject matter, in particular on orchestrating whole class dialogues in mathematics with a focus on pupils' learning. We argue that UM's active participation in combination with mentoring based on videos of the student teachers' own teaching proved to be successful. The mentoring in our study is more oriented towards subject matter and learning than shown in previous studies (e.g. Bradbury & Koballa, 2007; Helgevold et al., 2015; Strong & Baron, 2004). In line with Rosaen et al.'s study on interns (2008), when using video, we see a shift towards an increased focus on instruction and pupils and less focus on the performance of the teacher. In despite of this shift, we have no reason to believe that the student teachers in our study desired more emotional support. On the contrary, the student teachers express in their logs that their insufficient performance was not the focus and that it felt irrelevant who performed the classroom dialogue. We see this as signs of a safe environment where they had a joint ownership of the planning, the teaching and their own learning.

What is the impact of our study? Our study has shed further light on the reported difficulties novice teachers have with orchestrating whole class dialogues (Henning & Lockhart, 2003; Author, 1995). Thus, the study elucidates the continues need for focused training on orchestrating whole class dialogues in mathematics, and as part of this, how to represent the pupils' strategies. We add to the field showing how university lecturers and school-based mentors together can focus such training as part of student teachers' field practice using video as a mediating tool, - focused training through focused mentoring. However, we are aware that such co-mentoring is resource heavy in terms of staff time. We

propose that collaborative video-based mentoring is carried out once or twice a year. In programs where the university mentors already have a role in field practice, this could be achieved by redistributing time already spent on classroom observations to more time on focused mentoring. For further studies in video-based mentoring in initial teacher education, it would be interesting to follow one student's development of orchestrating whole class dialogues in mathematics over a longer period of time. It would also be interesting to study video-based mentoring focusing on whole class dialogues in other subjects.

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APPENDIX

Table 1: Thematic focus of the mentoring based on video clips from Hannah's whole class dialogue (autumn).

Sequence	Duration of the video sequences discussed	Focus in the video clip from the classroom	Duration of the discussion connected to the single video clip	Who stopped the video	Topic discussed in the mentoring conversation
1	1 min 10 sec	Teacher's presentation of an addition task	1 min 27 sec	PM	Classroom management, creating an environment with time to think
2	1 min 10 sec	Pupil presenting her idea and the teacher repeating it	8 min 26 sec	UM	Interpreting pupil's ideas and choice of **representations**
3	2 min 1 sec	Interpreting one pupil's idea through dialogue with another pupil and the class, writing down the task and pointing at the board	4 min 41 sec	UM	Interpreting pupil's ideas and choice of **representations**
4	1 min 17 sec	Pupils thinking on a task, then sharing their ideas in peer groups	2 min 7 sec	UM	The need to monitor the pupils' talk while they are working
5	2 min 2 sec	Whole class dialogue about different calculation strategies including oral interpretation of two pupils' joint idea	3 min 11 sec	UM	Ways of **representing** the pupil's idea on the board
6	2 min 10 sec	Pupils thinking on a task, then sharing their ideas in peer groups	2 min 35 sec	Han-nah	Student teacher explaining why she monitored a peer group
7	2 min 15 sec	Pupil presenting his idea and the teacher interpreting it and pointing at the different tasks on the board	7 min 19 sec	UM	Choice of representations **Representing** pupils' ideas in whole class dialogues and ways of including the other pupils
8	2 min 21 sec	Two pupils presenting each their ideas, the teacher interpreting it orally and writing on the board	2 min 5 sec	UM	Interpreting the pupils' ideas and choice of **representations**
9	2 min 25 sec	Interpreting a pupil's idea orally with support from different pupils	10 min 42 sec	PM	Limits regarding use of pupils' ideas in whole class dialogues The need for efficiency improvements through foreseeing and choice of examples and ways of **representing**
Hannah – whole class dialogue: 33 min/mentoring session: 59 min					

Table 2: Thematic focus of the mentoring based on video clips from Ann's whole class dialogue (autumn).

Sequence	Duration of the video sequences discussed	Focus in the video clip from the classroom	Duration of the discussion connected to the single video clip	Who stopped the video	Topic discussed in the mentoring conversation
1	2 min 11 sec	Dialogue with two pupils presenting their idea showing a picture on the board	2 min 50 sec	Ann	Teacher's questions language accuracy
2	1 min 43 sec	Dialogue with the class interpreting the two pupils' idea pointing at a picture of the pupils' solution	6 min 36 sec	PM	**Representing** the pupils' idea on the board Language accuracy
3	20 sec	Part of dialogue with two pupils presenting their idea orally	6 min 10 sec	UM	Choice of pupils' ideas to be presented in the whole class dialogue
4	3 min 12 sec	Dialogue with two pupils presenting their idea at showing a picture on the board	6 min 17 sec	UM	**Representing** the pupils' idea on the board
5	3 min 30 sec	Dialogue with two pupils presenting their idea showing a picture on the board, the student teacher interpreting and representing the idea on the board	9 min 54 sec	UM	**Representing** the pupils' idea on the board
Ann – whole class dialogue: 44 min/mentoring session: 46 min					

Table 3: Thematic focus of the mentoring based on video clips from Laura's whole class dialogue (spring).

Sequence	Duration of the video sequences discussed	Focus in the video clip from the classroom	Duration of the discussion connected to the single video clip	Who stopped the video	Topic discussed in the mentoring conversation
1	1 min 30 sec	Dialogue with one pupil about his calculation strategy connected to a task represented by a figure on the board	4 min 8 sec	UM	How to **represent** the pupils' calculation strategies on the board as a bridge to the introduction of multiplication. Time to think
2	1 min 12 sec	Whole class dialogue about the pupils' different calculation strategies pointing at representation on the board	2 min 10 sec	UM	**Representing** the pupils' ideas on the board in a whole class dialogue and possible efficiency improvements
3	3 min 22 sec	Whole class dialogue about the pupils' different ideas and how to represent them by numbers (addition and multiplication)	2 min 27 sec	UM	_ " _
4	1 min 40 sec	Whole class dialogue about the pupils' different calculation strategies connected to a new representation on the board	1 min 46 sec	PM	**Representing** pupils' ideas on the board in order to include all the pupils in their thinking
5	1 min 55 sec	Whole class dialogue about the pupils' different calculation strategies - representing their ideas by using numbers on the board (addition and multiplication)	9 min 8 sec	UM	**Representing** a pupil's idea about doubling on the board in order to include all the pupils in his thinking Possible efficiency improvements to come quicker to the point (multiplication)
6	1 min 5 sec	Whole class dialogue about the pupils' different calculation strategies pointing at representation on the board	3 min 22 sec	PM	Interpreting and **representing** a pupil's idea
7	4 min	Dialogue with one pupil about her idea – interpreting it and pointing at the representation on the board	2 min 14 sec	PM	Interpreting a pupil's idea
8	2 min 15 sec	Dialogue with one pupil about her idea – interpreting it and representing it by using numbers on the board (multiplication)	40 sec	UM	Interpreting and **representing** a pupil's idea
9	1 min 48 sec	Whole class dialogue about the pupils' different calculation strategies pointing at the different representation on the board	6 min 53 sec	PM	**Representation** with focus on doubling The need for efficiency improvements
Laura – whole class dialogue 29 min/mentoring session: 52 min					

Table 4: Thematic focus of the mentoring based on video clips from Mary's whole class dialogue (spring).

Sequence	Duration of the video sequences discussed	Focus in the video clip from the classroom	Duration of the discussion connected to the single video clip	Who stopped the video	Topic discussed in the mentoring conversation
1	1 min 45 sec	The teacher reads the task and two pupils present their idea using a picture on the board and orally	5 min 20 sec	UM	Interpreting and **representing** the pupils' idea
2	1 min 4 sec	Interpreting and representing the pupils' ideas	3 min 10 sec	Mary	Teacher's questions and choice of **representations**
3	1 min 5 sec	Presentation of new task and the pupils' reactions	15 sec	PM	Pupils' motivation for new knowledge
4	2 min 6 sec	Whole class dialogue about division task	1 min 53 sec	UM	Teacher's questions
5	41 sec	_ " _	1 min 3 sec	PM	_ " _
6	2 min	_ " _	5 min 35 sec	PM	Teacher' focus in the whole class dialogue Efficiency improvements
7	1 min 4 sec	The teacher presents a former task two pupils will present their solution to	1 min 23 sec	Mary	The pupils' motivation and energy
8	11 sec	Whole class dialogue about division task	2 min 34 sec	UM	Choice of focus and **representations**
9	48 sec	Teacher's presentation of a task	42 sec	PM	Teacher's question
10	1 min 13 sec	Whole class dialogue about division task	1 min 27 sec	Mary	Interpreting and **representing** a pupil's idea Efficiency improvements
11	1 min 50 sec	Interpreting and representing a pupil's idea	1 min 3 sec	Mary	Teacher's focus and choice of **representations**
12	51 sec	Teacher's presentation of a task	51 sec	UM	_ " _
13	32 sec	_ " _	2 min 19 sec	PM	Teacher's focus and questions
14	2 min 40 sec	Whole class dialogue about division task Pupil showing her idea by writing on the board Interpreting and representing the pupil's idea	4 min 20 sec	UM	Teacher's focus on the goal in the whole class dialogue and the learning outcome
Mary – whole class dialogue: 28 min/mentoring session: 54 min					