Learning professional noticing by co-planning mathematics instruction

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At the core of ambitious mathematics teaching involves using knowledge of students' mathematical thinking when facilitating and leading mathematical discussions. A teacher's ability to productively use this knowledge depends on his/her noticing expertise. This study explores in-service teachers' opportunities to develop their ability to notice through a practice-based approach to professional development. Fourteen Norwegian elementary-school teachers collaborate with teacher educators in learning cycles of enactment and investigation, where the overarching aim is to learn to enact ambitious mathematics teaching. This study investigates what this innovative approach enables teachers to work on when co-planning to notice. The findings suggest that the co-planning discussions focused on particular students' mathematical thinking (focused noticing) and on both students' mathematical thinking and teacher's pedagogy (extended noticing).

Keywords: Professional noticing, co-planning, mathematics teaching, learning cycles of enactment and investigation.

Introduction

The aim of this paper is to explore teachers' opportunities to learn professional noticing when collectively planning (co-planning) mathematics instruction. In any profession "we are sensitized to notice certain things" (Mason, 2002, p. xi) and the teaching profession is no exception. This "sensitized noticing" is often referred to as professional noticing, but hereinafter we will use the terms noticing and professional noticing interchangeably.

Informed by the extensive research base on students' mathematical thinking (e.g. Lester, 2007) and reviews of research suggesting that one of the core activities of teaching is "sizing up students' ideas and responding" (Ball, Lubienski, & Mewborn, 2001, p. 453), building instruction on students' mathematical thinking has been endorsed in many reform documents (for the Norwegian context, see Utdanningsdirektoratet, 2019). Students' mathematical thinking (students' thinking) refers to strategies, representations and reasoning students use in an instructional setting. Students' thinking is a coherent and logical approach to reasoning that often differs from the way mathematicians and other adults think (Carpenter, Carpenter, Franke, Levi, & Empson, 2015). Teachers' professional noticing can be defined as an expertise that includes attending to students' thinking, interpreting their understanding and deciding how to respond (Jacobs, Lamb, & Philipp, 2010). For teachers, noticing students' thinking is essential and research has suggested that developing the ability to notice can be learned through scaffolded support and collaboration (e.g. Star, Lynch, & Perova, 2011). The aim of professional development (PD) is therefore to support teachers in learning the demanding endeavour of noticing students' thinking, often referred to as ambitious teaching (Lampert et al., 2013).

Ambitious mathematics teaching aims to develop all students' conceptual understanding, procedural knowledge and adaptive reasoning (e.g. Lampert et al., 2013). Two principles of ambitious teaching are treating students as sense-makers and engaging deeply with their thinking. Examples of core

practices of ambitious mathematics teaching are eliciting, responding to and representing students' thinking and facilitating student talk.

Using student thinking during instruction is valued by the mathematics education community, yet ambitious practices to support such use remain difficult for teachers to enact well, particularly in the moment during whole-class instruction. In the *Mastering Ambitious Mathematics teaching* project (MAM), teachers were invited to collaborate in learning cycles of enactment and investigation (learning cycles) in order to develop their ability to notice students' thinking and to build on students' thinking in their teaching. For the purpose of this paper, the analysis intends to shed light on the ways in which co-planning instruction enabled teachers to collectively learn to notice professionally.

Professional noticing

The idea of noticing as a discipline sees noticing as a collection of ambitious practices. Each practice is designed to "sensitize oneself so as to notice opportunities in the future in which to act freshly rather than automatically out of habit" (Mason, 2011, p. 35). Noticing builds on the concept of professional vision as a process through which teachers make sense of what occurs during teaching and through which they make plans to respond to students' thinking (Sherin, Russ, & Colestock, 2011). Since ambitious teaching practices are difficult for teachers to enact well, predicting student strategies and discussing "what one wants to notice" (Mason, 2011, p. 48) are important steps in the ability to notice in the moment of whole-class instruction.

Ball (2011, p. xii) sees noticing "as a practice essential to attending to learners, to the domain for which the teacher is responsible, and to connections between the learners and the domain." Noticing is consequential, it is an awareness that enables action (Mason, 2011) and skilled teachers are quicker to identify situations that require intervention (Miller, 2011). Noticing has consequences for what a teacher sees and does not see, and for what a teacher does and does not do. Noticing is thus "a key component of teaching expertise and of mathematics teaching expertise in particular" (Sherin et al., 2011, p. 79) because it can lead to changed practices, where planning for such practices is necessary.

Even though there are various conceptualizations of noticing (Miller, 2011), the two interrelated and cyclical processes of attending to and making sense of particular students' thinking in an instructional setting are often involved. For example, Star et al. (2011) include what a teacher attends to as well as what the teacher decides not to attend to in their conceptualization of noticing. Jacobs, Lamb, Philipp and Schappelle (2011) also include what teachers' plan to respond to in a classroom activity in their understanding of noticing. These researchers thus include the following in their characterization of noticing: how teachers pay attention to a classroom activity, their interpretation of the activity and how they intend to respond. For the purpose of this paper, the term professional noticing is considered to include a) attending to students' thinking when co-planning instruction and b) deciding how to respond based on prediction of students' thinking (Jacobs et al., 2010).

Noticing in teaching is suggested as "special" and "unnatural" (Ball, 2011, p. xxi). When working closely with a group of experienced teachers, Empson and Jacobs (2008) found that the teachers were unprepared to be responsive to students' thinking. Noticing is thus important for professional development (PD). In order to learn to notice students' thinking, an interrelated and situated set of skills for attending to their thinking is required. As these skills are specialized, a significant shift in how teachers conceptualize their role is required (Empson & Jacobs, 2008). Although not usually

developed in teacher education programs (e.g. Ball, 1993), and taking years to learn (e.g. Empson & Levi, 2011), these skills are learnable with sustained PD (e.g. van Es & Sherin, 2008).

In the MAM project, our focus situates teachers in the authentic work of teaching through *learning cycles of enactment and investigation* (learning cycles). Building on the importance of being prepared to notice students' thinking (Mason, 2011), we investigate how co-planning enables teachers to collectively learn to professionally notice their thinking.

Methodology

The work is informed by social views on teacher learning and a key part of this perspective is to view learning as it emerges in activities. From this perspective, teacher learning includes developing the ability to engage in particular (ambitious teaching) practices (Lave, 1991) in learning cycles in PD. In the MAM research project, fourteen Norwegian elementary-school teachers worked together in two groups in repeated learning cycles with the aim of learning core practices and principles of ambitious teaching. Each group was guided by a teacher educator (supervisor) and the group structure enabled them to work together in co-planning, rehearsing, co-enacting and analyzing instruction. The participants met for nine full learning cycles over the course of two years, resulting in 18 videotaped cycles. In this paper, the analyzed data material is from video recordings of the co-planning sessions where teachers together with their supervisor collectively planned instruction.

A framework developed by van Es (2011) was used to analyze the depth and analytic stance of noticing in teachers' co-planning discussions. This framework includes an identification of "what is noticed and how teachers reason about what they observe", as well as "a trajectory of development in these two dimensions from Baseline to Extended Noticing" (van Es, 2011, p. 138). For the purpose of this paper, the focus is on *what* teachers plan to notice, using the dimensions from van Es's (2011) "*What* Teachers Notice" (Table 1).

Table 1: Framework for learning to notice student thinking (adapted from van Es, 2011, p. 139)

	Level 1 Baseline	*Level 2 Mixed*	*Level 3 Focused*	*Level 4 Extended*
What Teachers Notice	Planning to attend to whole class environment, behavior, and learning and to teacher pedagogy	Primarily planning to attend to teacher pedagogy Planning to begin to attend to particular students' mathematical thinking and behavior	Planning to attend to particular students' mathematical thinking	Planning to attend to the relationship between particular students' mathematical thinking and between teaching strategies and student mathematical thinking

We undertook a three-step analysis. First, co-planning sessions were divided into episodes where the change of topic defined a new episode. Second, each episode was divided into sequences which were coded according to the framework of learning to notice (van Es, 2011), including four levels of noticing – baseline, mixed, focused and extended levels. Each level of noticing represents what the teachers in collaboration with the teacher educators plan to notice. Their attention to whole-class

observations or teacher pedagogy represents lower levels of noticing. At higher levels of noticing, the focus is on particular students or connections between teaching and student learning. Descriptive and evaluative comments represent a lower level of noticing, while higher levels of noticing are characterized by a focus on students' thinking. Lastly, a qualitative in-depth analysis of sequences was conducted to identify and explore examples of noticing on different levels. Sequences and not individual utterances were considered as the unit of analysis, and in this in-depth analysis the sequences were explored using van Es's (2011) framework (Table 1). In this study, a representative example from selected sequences in one co-planning session has been chosen to present our findings from the second and third step of the analysis.

Findings

We have previously identified three visible ambitious teaching practices that were particularly discussed in learning cycles (Fauskanger & Bjuland, 2019). One of these practices – particularly worked on during the co-planning sessions – was to predict student strategies for finding the number of dots in the quick image (Figure 1). The other two practices were to represent student ideas in the quick image and to aim towards a mathematical goal for the lessons. In the present study, we have been particularly concerned with these three practices when digging deeper into the learning cycles using the learning to notice framework (Table 1) as the basis for our analysis, and thereby investigating the teachers' opportunities for learning to notice students' thinking when co-planning instruction.

Throughout the co-planning sessions, there were few sequences where the teachers appeared to be concerned with themselves and their own practices (baseline noticing, Level 1). There were some examples of mixed noticing (Level 2). The major parts of the co-planning sequences focused on particular students' thinking alone or together with teacher's pedagogy (focused noticing and extended noticing, Level 3 and Level 4), highlighting the teachers' opportunities for engaging in these particular noticing practices and thus providing opportunities for learning them (Lave, 1991).

Two related sequences from one co-planning session particularly focusing on predicting student strategies as one ambitious teaching practice will be used to illustrate the focused and extended noticing in the co-planning sessions. The first example is a brief sequence in the co-planning discussion.

Focused noticing: attending to a student response related to teaching strategy

The participants have been working on predicting student strategies for finding the number of dots in a quick image, as shown in Figure 1. In the continuation of the discussion, one of the teachers, T4, implicitly recapitulates the particular student strategy 3×5 and 3×4, paying attention to the relation between this strategy and a prediction of how students will see 15 in the quick image (39):

39	T4:	I think that some [students] would think that they see 15, right?
40	S:	Yes, that they see the whole [top row].
41	T4:	They know, they have played Yatzy and they know that it's 15, it's nothing more than that.

The supervisor (S) makes a supportive contribution and expresses agreement, seeing the first row (Figure 1) as "the whole".

Figure 1: The predicted strategy 15 + 12 represented on the board

We could argue that this brief dialogue on the co-planning discussion illustrates an example of focused noticing (Level 3, Table 1) and planning to attend to particular students' thinking since T4 is paying attention to one predicted student strategy. By predicting that students will see 15 in the quick image as three groups of 5 (3 × 5), T4 also indicates an awareness of the students' familiarity with the game of Yatzy (41). This indicates that T4 might also be knowledgeable about the basis for students' thinking, namely Yatzy.

Extended noticing: attending to the relation between different student strategies

In the following, we dig deeper into a longer sequence, illustrating indications of extended noticing (Level 4, Table 1).

145	S:	Yes, but if we look at exactly this picture [points to the quick image where 15 is marked]. If we [discuss] the students who see 15 here.
146	T2:	But they quickly see 12 on all, yeah.
147	S:	So you think that [they see] 15 plus 12?
148	T2:	Yes, they might do that.
149	S:	Yes [writes +12 on the board next to 15].
150	Many:	Yes.
151	T4:	Then I'm thinking a bit in relation to if you take 15, [you can ask the students] "how do you see 15 here?"
152	S:	Yes [at the same time frames the three fours].
153	T4:	Then this is three times five or five times three, plus and then [you can ask the students] "How do you see 12 here"?
154	S:	Yes.

The discussion illustrates how the participants' utterances are related to each other, building on and elaborating on each other's initiatives. Levels of noticing are therefore difficult to code utterance by utterance. However, looking at the whole sequence, we observe how the participants recapitulate predicted student strategies and discuss how these strategies might be represented in the quick image. T4 predicts that some students will see the three fours as 12 (146-148), and this representation is illustrated by the supervisor by circling the three fours as one 12 (152, see Figure 1). The discussion reveals how the participants decide to ask the students how they saw the 15 and the 12 in the quick image. In this sequence of the co-planning discussion, we learn that the teachers and their supervisor attend to the relationship between particular students' mathematical thinking, the relation between predictions of different student strategies and between representing student ideas in the quick image. We observe that the supervisor is the one who points to this relationship between student thinking and the ambitious teaching practice of representing student ideas in the quick image. The crucial role of the supervisor was visible in many co-planning sequences indicating extended noticing.

In the following sequence, the supervisor also challenges the teachers to see the predicted student

strategies in relation to the goal for the lesson by saying:

> S: Yes, fine, but then I think that we have arrived at some possible strategies [points at the predicted student strategies written on the board]. In a way, then the question is: What direction do we want to take [in the instruction]? Because some of the suggested strategies we have might pull us in one direction related to the goal and another [strategy] might pull us in a different direction.

This suggests a focus on particular students' mathematical thinking in relation to the goal for the lesson. It also illustrates the relationship between particular students' mathematical thinking and instruction, and that focused and extended noticing (Level 3 and Level 4) go hand in hand throughout the co-planning sessions.

Concluding discussion

Noticing is an awareness that enables action (Mason, 2011) and in the co-planning sessions in the learning cycles in the MAM project the predicted student strategies and actions discussed might be such an awareness. These results are interesting and promising. They differ somewhat from studies of teacher noticing in video clubs (e.g. van Es & Sherin, 2008) and in post-lesson discussions in lesson study cycles (e.g. Karlsen & Helgevold, 2019). By using the analytic stance of noticing (van Es, 2011), Karlsen and Helgevold (2019) shed light on teachers' attention to student learning, using notes from classroom observations to identify interactions in post-lesson discussions that can influence teachers' professional noticing. Their findings provide important insights into how such discussions may extend or narrow levels of noticing. In a similar way, our analysis points to the opportunities for learning to notice students' thinking when co-planning instruction. It seems that co-planning in learning cycles invites teachers to learn higher levels of professional noticing. At these higher levels, the participants do not only attend to teacher pedagogy and student behavior, but to particular predicted students' thinking and to teaching strategies building on students' thinking (van Es, 2011). The role of the supervisor seems, however, to be of crucial importance for moving the co-planning discussion to higher levels of noticing.

One element of the MAM project's learning cycles of enactment and investigation, namely co-planning sessions, has been analyzed and we gain insight into how these sessions create learning situations for teachers' collective learning of professionally noticing students' mathematical thinking. In conclusion, while planning to attend to predicted students' strategies, it appears that co-planning sessions in learning cycles are contexts where teachers can learn to size up students' ideas (Ball et al., 2001). When discussing how to respond to students' thinking by representing their ideas in the quick image (Figure 1), the participants also discuss how to base instruction on predicted students' thinking (Carpenter et al., 2015; Empson & Jacobs, 2008) and thus plan to attend to the relationship between particular students' thinking and between teaching strategies and student thinking. Developing the ability to notice and in particular *what* to notice (van Es, 2011) can be learned through scaffolded support and collaboration (e.g. Star et al., 2011). Our analysis indicates that the learning cycles in the MAM project, and in particular the supervisor's active role in these sessions, provide the participants with this type of scaffolded support.

While this study offers some insight into learning professional noticing by co-planning mathematics instruction in the context of PD, more research is needed in this field. Compared to studies of teacher noticing in video clubs (e.g. van Es & Sherin, 2008) and in lesson study cycles (e.g. Karlsen &

Helgevold, 2019), the co-planning in learning cycles seems to invite teachers to learn higher levels of noticing. However, to be able to make clearer conclusions, we need to provide systematic descriptions of each element of the learning cycles and develop understanding of how the different elements enable teachers to collectively learn professional noticing. The role of the supervisor is also yet to be explored. Moreover, studying possible ways in which teachers might learn together how to notice (van Es, 2011) in all elements of learning cycles and how the learning within this project might lead to changes in their classroom practice will also be of importance for future research.

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