Rehearsals in work with in-service mathematics teachers

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An approach that has shown to give pre-service teachers rich opportunities for learning to teach mathematics is through a cycle of enactment and investigation. An important part of the cycle is rehearsal where novices rehearse their plans for enacting particular instructional activity in front of their peer pre-service teachers. The peers and the course instructor take part in the rehearsal as students, and every participant can stop the activity for discussion on different aspects in teaching. We build on the approach developed for pre-service teachers, and work on the adoption and development of the approach for work with in-service teachers in Norway. This paper reports from a pilot that was implemented with a group of in-service teachers. Our research question concerns interactions between in-service teachers and course instructors during the rehearsals and in-service teachers´ opportunities for learning in rehearsals.

Keywords: Rehearsals, in-service teachers, ambitious teaching.

Introduction

The aim of mathematics instruction is development of mathematical proficiency, which is characterized by conceptual understanding, procedural fluency, adaptive reasoning and productive disposition towards mathematics (see Kilpatrick, Swafford, & Findell, 2001). This ambitious goal leads to a more demanding, and thus ambitious, conception of mathematics teaching. In this paper we aim to add to the existing knowledge base about how teacher education can support in-service mathematics teachers to learn the work of ambitious mathematics teaching.

In the Mastering Ambitious Mathematics Teaching (MAM) project we develop a course for in-service mathematics teachers in Norway. In designing our intervention, we take our lead from the Learning in, from, and for Teaching Practice (LTP) teacher education project (see Kazemi & Hubbard, 2008; Kazemi, Lampert, & Franke, 2009; Lampert et al., 2010; Lampert et al., 2013; Kazemi & Wæge, 2015). Central in the LTP-practice based approach is work with specifically designed instructional activities (IAs) in a cycle of enactment and investigation. A key innovative feature of the design is the use of public rehearsals. In a rehearsal, the pre-service teacher is responsible for teaching an IA to a group of peer pre-service teachers acting as students, with the course instructor offering guidance.

This paper reports on our work on rehearsals with *in-service* teachers in a pilot study. We ask: What characterizes the interactions between in-service teachers and course instructors during the rehearsals in the study, and in what ways might rehearsals support in-service teacher´s learning of ambitious teaching?

Rehearsals within a cycle of enactment

Ambitious teaching entails mathematical meaning making, identity building and creating equitable learning experiences for children. It requires teachers to engage deeply with children's thinking - by eliciting, observing, interpreting and responding to student reasoning, language and arguments. Attending to students' experiences and designing instruction to enable each child to do rigorous academic work in school is also a central principle of the approach (Lampert et al., 2013).

In their work on ambitious mathematics teaching, Lampert et al. (2010) build on the study of Leinhardt and Steele (2005) who identified some routines skilled teachers used in leading instructional dialogues and argued that expressing the routines explicit make them teachable for course instructors. Lampert et al. (2010) use the notion "routines" to denote well-developed practices which have shown useful in teaching, which respect the complexity in mathematics, mathematics teaching and learning. They argue that focus on learning to use these routines/practices can provide novices an opportunity to hold something constant in a process of further learning to teach. The teaching practices that are central in ambitious teaching include aiming toward a mathematical goal, eliciting and responding to students' mathematical ideas, orienting students to each other's ideas, setting and maintaining expectations for student performance, positioning students competently, assessing students' understanding, and using mathematical representations (Kazemi et al., 2009; see also Hunter & Anthony, 2012). Teachers who are novices in teaching mathematics ambitiously need to learn to enact the practices in their teaching. They also need to develop the mathematical knowledge needed to teach ambitiously at a particular grade.

Grossmann, Hammerness and McDonald (2009) argue for incorporation of "pedagogies of enactment" and use of "approximations of practice" in teacher education in order to help pre-service teachers develop knowledge, skills and professional identities as teachers. As a type of approximation to practice, Grossmann, Compton at al. (2009) suggest use of rehearsals where novices rehearse a particular instructional activity in front of a group of peers. Kazemi, Lampert and Franke (2009) develop instructional activities (IAs) that are designed to be "containers" for the practices, principles and mathematical knowledge that novice teachers need to learn and be able to use in interaction with students (see Kazemi & Wæge (2015) for descriptions of the IAs). The structure of the IAs offers the novices a scaffold in eliciting and responding to student thinking and understanding. The novice teachers learn to teach IAs – through repeated investigation, discussion, rehearsal, enactment and observation. Each cycle of enactment and investigation consists of six stages (Lampert et al., 2013), as illustrated in Figure 1:

1) Observation of a teacher educator´s enactment of a particular IA
2) Collective analysis of the observed enactment
3) Preparation to teach the IA to a group of students
4) Rehearsal of the IA by novice teachers
5) Enactment of the IA with a group of students
6) Guided collective analysis of the enactment

Figure 1: Cycle of enactment and investigation

In stage four of the cycle, selected novice teachers publicly rehearse their plans for enacting an IA in front of their peers and with feedback from the course instructor. During the rehearsal, the course instructor or a peer may stop action to ask questions or suggest possible alternative courses of action. The course instructor may also act as a student, by asking and answering questions or by making errors that students are likely to make (Lampert et al., 2013). Rehearsals within repeated cycles of enactments and investigation can be considered as an approximation of ambitious teaching.

Lampert et al. (2013) argue that a rehearsal is an important setting for building novices motivation and commitment to teach ambitiously (p. 239-240). They analyzed 90 rehearsals of IAs by pre-service teachers. The study revealed that rehearsals not only allow pre-service teachers to work on routine aspects of ambitious teaching, but also to attend to more complex aspects of it. The study also showed that rehearsals give the pre-service teachers an opportunity to learn the principles of ambitious teaching while the course instructor guide their progress.

Design of course

The course consisted of seven sessions (each four hours in length) during a period of four months. The sessions were held in a fifth grade classroom of an elementary school[1].

Session 1: The in-service teachers (ISTs) were introduced to the principles and practices central to ambitious teaching and the instructional activities they would work on during the course.

Session 2-6: In these sessions ISTs were divided into three teams of 4-5, and the teams worked together in planning, rehearsing, enacting, and debriefing course tasks: 1) Teams of ISTs came to class prepared to teach an IA; 2) Teams of ISTs rehearsed the IA under supervision of a course instructor (CI); 3) ISTs observed one of the CIs teach the subsequent session's focal IA to the whole group of fifth graders. This was part of the preparation for the following session; 4) One IST from each team taught a small group of fifth graders the IA that they had come to class prepared to teach. A CI also observed the enactments; 5) After a break, ISTs met in their teams to do a collective analysis of the day´s enactment with their CI; 6) Each team debriefed what they had learned; 7) The CIs prepared the class for the following session's focal IA and, as part of that, shared some reflective comments on the whole group lesson that was taught.

Session 7: The last session was devoted to concluding discussions and try outs.

Method

Participants and data

There were 14 in-service mathematics teachers from three different elementary schools participating in the pilot study. The three schools are partner schools of the Norwegian Centre for

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[1] Due to practical reasons we had to make some changes to the cycles of enactment and investigation proposed by Lampert et al. (2013) and illustrated in Figure 1.

Mathematics Education. Some of the ISTs in the study had only a few years of experience as mathematics teachers, while others were experienced teachers. A group of six course instructors (including both authors) from the Centre participated in the study. The course instructors had little experience in leading rehearsals.

Rehearsals were carried out in three teams at five of the sessions. All rehearsals were videotaped, but two of the recordings were damaged. Our data is therefore consisting of 13 recordings. Each recording is about 25 minutes.

Coding and data analysis

A rehearsal consists of parts where an IST is teaching the activity, and parts where IST(s) and CI interact. We denote the interactions between IST(s) and CI during the rehearsal as *CI/IST exchanges*. To understand what characterizes the CI/IST exchanges during rehearsals, we take a CI/IST exchange as the unit of analysis and we analyze: 1) the substance of exchanges between CIs and ISTs, and 2) the structure of exchanges between teacher CIs and ISTs. In our analysis we used a priori codes adopted from Lampert et al. (2013). Table 1 shows a list of the substance codes and Table 2 shows a list of the structure codes that we built our analysis on. We used Studiocode video-analysis software which allowed for detailed coding of the rehearsals. For each rehearsal, we created a timeline for each video-recorded to capture the substance and structure of exchanges. Coding the video directly allowed for both verbal and visual cues to be considered, such as written representation, gesturing, and movements.

Results

Substance of CI/IST exchanges

In Table 1 we present an overview of frequency of the various substance codes in all CI/IST exchanges in the data[2]. The most frequent codes in our data are *representation, student thinking, content goals* and *elicit and respond.* These codes were also among the most frequent in the rehearsals by pre-service teachers analyzed by Lampert et. al (2013).

Substance codes	Description	% of all exchanges
assessing understand.	Assessing what a student knows and understands about the mathematics	16,1
attending to IA	Drawing attention to the structural aspects of the IA, particularly to help novice teachers´ understanding the entire IA	23,1
body/voice use	Attending to how one uses body and voice while teaching	0
closing the IA	Bringing the IA to an end	3,5
content goals	Attending to the specific mathematical content goals of the lesson	31,5
elicit and respond	Eliciting, interpreting, responding to student mathematical work or	31,5

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[2] Due to the complexity of CI/IST exchanges, an exchange can be coded by several substance codes. As a consequence, the percentages do not sum to 100%.

	talk	
launching the IA	Introducing and beginning student engagement with the IA	5,6
manage space	Attending to issues of classroom space while engaging students	0,7
manage timing	Moving through the lesson in a way that manages timing and pacing	3,5
mathematics	Working on and understanding the mathematical content, particularly for IST learning	22,4
orienting students	Orienting students toward each other´s mathematical ideas	7,0
process goals	Attending to the specific mathematical process goals of the lesson	16,1
representation	Representing mathematical ideas in writing and making connections between talk and representation	39,2
student engagement	Managing the intellectual and behavioral engagement of students	12,6
student error	Surfacing and responding to student errors	4,9
student thinking	Attending to the details of student mathematical thinking	32,9

Table 1: Substance codes: description and frequency as percentage of all CI/IST exchanges in the data

Many of the CI/IST exchanges involved more than one substance code, and the same combination of substance codes were frequently found together across different exchanges. For example, *student thinking*, *elicit and respond* and *representation* appear repeatedly in the same exchange. The combination of *content goal* and *representation* is also very common, in many cases together with *mathematics*. The frequency and the combination of the codes indicate that the main substance in CI/IST exchanges consist of

1) attending, representation, eliciting and responding to student thinking
2) content goals and representation of mathematical ideas in the activity

The following example is representative of the first category above:

Example 1. The IST who is teaching during the rehearsal shows the image of three groups of eight dots and asks the "students" how they see it. One of the other ISTs in the team suggest an answer.
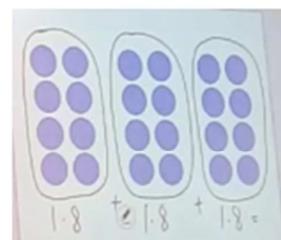

Figure 2: Drawing on the whiteboard

IST2:   I see eight times three. In the first group I saw four plus four, eight. I have eight three times.

IST: [Circles three groups of eight. See Figure 2.] So first you have one times eight, so one times eight, so one times eight. [Writes 1x8+1x8+1x8=3x8.] Some other suggestions?

CI: Can we stop for a moment? Hmm, this is not so easy. The student presents her thinking rather imprecisely, and now we need to illustrate it on the image and also write it symbolically. We lose the part about seeing eight as four plus four in the way you represent her thinking. Can we try to represent her idea more accurately?

IST:	I can circle four and four…
IST3:	But just in the first group. She said that she saw it in the first group and then just multiplied by three. And it is not clear whether she thinks eight times three or three times eight, she says both.[3]
IST:	Yes, right. I tried to make "eight times three or three times eight" clearer by leading to one times eight, and so on. Because it is three times eight.
CI:	Maybe you can ask the student how she would represent it? Or, if you find her explanation too vague, you can ask her to say more?

The IST2 (who plays the role of the student) says that she sees eight as four plus four and she says "eight times three". Later she says "eight three times" which is more in accordance with the image and the convention. The IST takes no notice of the first parts of the utterance, and he grabs hold of the last part which is more in line with his goal. The CI´s first question is about *attending to* and *representation* of student thinking. The IST simplifies and changes the student´s contribution through the visual and symbolic representation. Further on, he asks for other suggestions and thus indicates that the discussion is finished. The CI´s second utterance explicitly addresses *eliciting and responding*.

The combination of *content goals* and *representation* of mathematical ideas in the activity appear also often within exchanges in our data, and the combination is illustrated in the following example:

Example 2. The IST´s goal is to use a string of problems to discuss multiplication by ten, hundred and thousand with the students. He starts by four times three, and asks the students for a story that would fit the arithmetic problem. A student (one of the ISTs) suggests four groups of three apples, and the IST draws the illustration as shown in Figure 3.
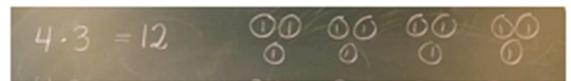

Figure 3: Illustration on the blackboard

CI:	Are you planning to use money in the discussion? Your illustration reminds me of money.
IST:	Yes, I have been thinking about it. Money can be useful here, when we discuss multiplication by ten, hundred. One can use tenths and talk about 12 tenths in the next step. Same with hundreds. But, another story came up.
CI:	As a teacher, you have decided what the content goal is, and you have been thinking about what representation would be appropriate. You can ask about a story *with* money from the start to get the representation you want in the discussion.

These kinds of exchanges, where *representation* and the *content goal* are combined, appear frequently in the data. In Example 2, the main substance discussed is the type of representation that

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[3] In Norway, when the multiplication is interpreted as equivalent groups, the meaning of "eight times three" is eight groups of three.

could be appropriate for a given content goal and how to introduce it. In some other exchanges in the data that are coded with these two codes, the discussion is on ways to represent mathematical ideas so that the representation emphasizes the the relations that are targeted in the activity.

Structure of CI/IST Exchanges

The structure codes used in our analyses are the same as those used by Lampert et. al. (2013). Table 2 shows the description and frequency of the various codes in our data. Similarly as with substance codes, an exchange can be coded using several structure codes. For instance, In Example 2 above, the exchange starts by "CI facilitates discussion" and develops to "CI gives directive feedback".

Structure-codes	Description	% of all exchanges
CI facilitates discussion	CI lead a discussion and reflection raised by CI or ISTs	50,4
CI gives directive feedback	CI suggests new move or think aloud about possible next move	35,7
CI gives evaluative feedback	CI make evaluative comment	7,7
CI scaffolds enactment	CI takes the role of teacher or student, scaffolding the enactment by either increasing or reducing the complexity	23,1

Table 2: Structure codes: description and frequency as percentage of all CI/IST exchanges in the data

Considering the structure of the rehearsals, the analysis shows that half of all CI/IST exchanges in our data can be characterized as *discussions facilitated by CI* (at least partly, in cases where several structure codes are used in the same exchange). In rehearsals analyzed by Lampert et. al. (2013), the code "CI facilitates discussion" is the least frequently appearing code, whereas "directive feedback" is the most frequent. This indicates that the structures of the rehearsals in the two studies are quite different. One reason can be that our study concerns in-service teachers while Lampert et al. (2013) report from their work with pre-service teachers. In-service teachers have more experience with teaching than pre-service teachers, and it is reasonable to expect that their skills in teaching and their identity as mathematics teachers are more developed. A consequence can be that both in-service teachers and course instructors working with them might feel more comfortable in discussions than with CI giving directive/evaluative feedback or scaffolding enactment.

Discussion

Further work with in-service teachers and further data collection will take place in the coming year, and the results presented here are preliminary. However, the pilot study has already yielded a number of valuable insights. The study shows that the interactions between ISTs and CIs during rehearsals are mainly in form of discussions on some central principles and practices of ambitions mathematics teaching - using mathematical representations, aiming toward a mathematical goal, attending to student thinking and eliciting and responding to students' mathematical ideas. More

specifically, we have found that multiple substance and structure codes are present within individual rehearsal exchanges, indicating that rehearsals offer in-service teachers the environment and opportunity to work simultaneously on a variety of aspects of practice.

The study of Lampert et. al (2013) shows that rehearsals give opportunities for pre-service teachers to learn to enact principles, practices and knowledge entailed in ambitious teaching. The findings in our study indicate that rehearsals function as an approximation of ambitious teaching in work with in-service teachers too, even though the structure of rehearsals is different.

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