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Bringing Nordic mathematics education into the future

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Preface

This volume presents Nordic mathematics education research, which will be presented at the Ninth Nordic Conference on Mathematics Education, NORMA 20, in Oslo, Norway, in June 2021. The theme of NORMA 20 regards what it takes or means to bring Nordic mathematics education into the future, highlighting that mathematics education is continuous and represents stability just as much as change.

NORMA conferences are always organized in collaboration with the Nordic Society for Research in Mathematics Education (NoRME). NoRME is open to membership from national societies for research in mathematics education in the Nordic and Baltic countries.

Inclusive classrooms and "mathematics education for all" have traditionally been at the core of Nordic mathematics education. Currently, the digital development and possibilities for individualized learning activities widen the understanding of adaption in compulsory education. This push and pull between inclusion and adaption bring the possibility of renewing mathematics education, including pre-school and tertiary levels, while still maintaining the principle of student-centred mathematics education. Mathematics education is also changing at the level of teacher education, which is reflected in the conference papers included in this preceeding.

The International Programme Committee (IPC) of NORMA 20 represents all Nordic countries and includes one representative from the Baltic countries, with a mix of junior and senior researchers. The IPC has organized the submission and review process leading to this volume. The members of the IPC were:

- Guri A. Nortvedt University of Oslo (Chair), Norway
- Nils Buchholtz, University of Oslo, Norway, and University of Cologne, Germany
- Janne Fauskanger, University of Stavanger, Norway
- Freyja Hreinsdóttir, University of Iceland, Iceland
- Markus Hähkiöniemi, University of Jyväskylä, Finland
- Britta Eyrich Jessen, University of Copenhagen, Denmark
- Jüri Kurvits, Tallinn University, Estonia
- Yvonne Liljekvist, Karlstad University, Sweden
- Morten Misfeldt, University of Copenhagen, Denmark
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- Hans Kristian Nilsen, Universitetet i Agder, Norway
- Guðbjörg Pálsdóttir, University of Iceland, Iceland
- Päivi Portaankorva-Koivisto, Helsinki university, Finland
- Jelena Radišić, University of Oslo, Norway
- Anna Wernberg, Malmö University, Sweden

The first NORMA conference on mathematics education, NORMA 94, was held in Lahti, Finland, in 1994. Four years later, the conference was held in Kristiansand, Norway; since then, it has taken place every third year. After each conference, selected papers are published in a proceeding. Due to the

COVID-19 pandemic, the NORMA 20 conference was postponed until 2021; however, many conference papers were in progress and authors were given the opportunity to continue working on them within the original planned timespan. Traditionally, papers are presented at the conference, allowing the authors to receive feedback that is valuable towards finalizing the paper. Instead, the authors have used two rounds of reviewer feedback to substantially improve their papers. In this process, the NORMA community established in 1995, together with external reviewers who are experts in the different fields studied and presented in the papers, have played an important role in producing the Preceeding.

We believe that the NORMA 20 Preceeding is the first conference preceeding to be published, containing 36 papers from authors representing six countries.

After the conference, a traditional Proceeding will be published, containing papers written by submitting authors who decided to wait until after the conference to finalise their papers, to take advantage of feedback from both conference participants and reviewers when they revise their papers.

The IPC would like to extend our thanks to all authors and reviewers for their efforts towards this volume.

Oslo, January 2021, on behalf of the IPC

Guri A. Nortvedt

How does professional development influence Norwegian teachers' discourses on good mathematics teaching?

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This study examines how practice-based professional development influences the discourse of a group of Norwegian primary mathematics teachers. Through cycles of enactment and investigation, in-service teachers (ISTs) learn teaching practices that constitute ambitious teaching. The teachers are interviewed before and after professional development and a coding-scheme from the analysis of the pre-interviews is used to analyze the post-interviews to find changes in how teachers conceptualize good mathematics teaching. The findings show that new categories emerge in how the teachers conceptualize good mathematics teaching.

Keywords: Professional development, cycle of investigation and enactment, ambitious mathematics teaching, the conceptualization of good mathematics teaching.

Introduction

Professional Development (PD) for teachers is an important part of the Norwegian government's desire to improve the quality of education (Kunnskapsdepartementet, 2015). PD can have varying content and can be organized in a number of ways. This study is part of a PD project (the MAM-project) where the main goal has been to support mathematics teachers in the development of their practice to achieve ambitious teaching. Ambitious teaching aims to engage all students in mathematical thinking and develop their conceptual understanding, procedural knowledge and adaptive reasoning through problem-solving (Lampert, Beasley, Ghousseini, Kazemi, & Franke, 2010). Students' ideas are at the core of ambitious teaching, and teachers need to respond to students' in-the-moment thinking respectfully and thoughtfully with the mathematical goal in mind. This study aims to explore how PD can influence the teachers' discourse on good mathematics teaching. This may provide insight into how this kind of PD influences teachers' norms for good mathematics teaching (Krainer, 2005) and will thus contribute to research on PD content and how it should be carried out (Maass, Cobb, Krainer, & Potari, 2019).

There is no common definition of what constitutes good mathematics teaching. There is, however, a growing body of research that examines the features of instruction that supports students' learning (Cai, Kaiser, Perry, & Wong, 2009). Core practices (McDonald, Kazemi, & Kavanagh, 2013), high-leverage practices (Ball & Forzani, 2011) and ambitious teaching practices (Lampert et al., 2013) are terms used to describe research-based practices that give all students opportunities to learn mathematics. Three features are at the core of such practices: shaping a mathematical discourse, developing classroom norms and developing relationships that enable all students to participate and learn mathematics in a supportive environment (Franke, Kazemi, & Battey, 2007). Even though there are some common understandings on features constituting good mathematics teaching, defining what it is seems to depend on the views of teacher educators and teachers. These views might also affect decisions made about instruction (Cai, et al., 2009; Li, 2011).

In recent years there has been a shift from focusing on the development of teachers' knowledge to developing teachers' practice (Zeichner, 2012). PD aims to support teachers in developing ambitious teaching (Lampert et al., 2010; Lampert et al., 2013). The project Learning to Teach In, From and Through Practice (LTP) provided novice teachers with opportunities for learning to enact ambitious teaching through cycles of enactment and investigation (Lampert et al., 2013). Recent research has examined how these cycles can be adapted and implemented with in-service teachers (ISTs) in the Norwegian context (Fauskanger & Bjuland, 2019).

Discourses on good mathematics teaching have been examined in several studies. For example, Hemmi and Ryve (2015) took a discourse-analysis approach to examine how Swedish and Finnish teacher educators conceptualized good mathematics teaching. They used the discourse concept "to refer to ways of interacting with the use of specific words and categories and how these constructions, in turn, produce the social actors of teachers and students within classroom practice" (Hemmi & Ryve, 2015, p. 502). One of the main findings in the study was the difference in how Finnish and Swedish teacher educators explicitly and implicitly position the teacher in the classroom practice. Fauskanger, Mosvold, Valenta and Bjuland (2018) focused on ISTs and how their discourse was constructed. They used Hemmi and Ryve's (2015) definition of discourse, and seven categories emerged in their content analysis of the data. Their findings reveal that Norwegian teachers position a shared responsibility for instruction between teachers and students.

In this paper, I ask the following research question: How does professional development influence teachers' discourses on mathematics teaching? I use directed and conventional content analysis (Hsieh & Shannon, 2005) of the teacher interviews to answer it.

Methodology

In the MAM project, a model and resources were developed to support the ISTs' professional development. The model builds on learning cycles (Lampert et al., 2013; McDonald et al., 2013) where specific instructional activities are used (Lampert et al., 2010). The structure of the activities offers scaffolding to ISTs for developing ambitious mathematics teaching, for instance, how they can use mathematical representations, teach towards an instructional goal, learn how to present the task, how to organize the blackboard, how to elicit and respond to students' thinking and understanding, and how to help the ISTs to focus on important mathematical ideas (e.g. Lampert et al., 2010). One of the characteristics of the activities is that they are suited for all students. The ISTs learn to teach the activities through learning cycles. Each cycle consists of six stages as described by Fauskanger and Bjuland (2019, pp. 130-131): 1) The ISTs prepare for the cycle by reading articles (e.g. about quick images) and by watching a video showing the enactment of the cycle's activity. Some ISTs try out the activity with their students. 2) One of the supervisors leads a discussion on the literature and the video. 3) The groups of ISTs plan the given activity for the given groups of students, supported by a supervisor. 4) In a rehearsal, one of the ISTs acts as the instructor. The supervisor and the other ISTs act as students. During the rehearsal, all participants can ask for teacher timeouts (TTOs). 5) The same IST enacts the activity with a group of students. All participants can ask for TTOs. 6) The enactment is analyzed by each group of ISTs together with their supervisor. This analysis is followed by a similar analysis with all the participating ISTs, and preparation for the next cycle's activity.

The project runs over four semesters, with three cycles each semester. Thirty teachers from ten schools have been selected by their principals to participate and have been assigned a future role in implementing ambitious teaching practices at their school. Most of the ISTs taught Years 5–7 (11–13 year old students). Their teaching experience varied from one to 30 years. Fourteen of the ISTs were purposefully chosen to be in the two research groups, bearing variation in age, education and teaching practice in mind.

The ISTs were interviewed in these two groups before and after PD (i.e. pre- and post-interviews). By conducting interviews before and after the PD work, it has been possible to look for changes in the ISTs' discourse. Hemmi and Ryve's (2015) definition of discourse, "ways of interacting with specific words and categories", has been used in the analysis. The focus is on how they interact with specific categories. With the analysis of the pre-interviews as the point of departure (Fauskanger et al., 2018), the data material analyzed in this paper comprises the videotaped post-interviews with the two groups of ISTs. After some talk about how they were going to implement ambitious teaching practices at their schools, the teachers discussed the same two questions as used in the pre-interview: 1) How would you characterize a good mathematics lesson? and 2) How would you characterize what for you is a "normal" mathematics lesson?

The videotaped post-interviews were transcribed. The unit of analysis was an utterance, and the coding-scheme used was developed from the analysis of the pre-interviews (Figure 1). This coding-scheme was developed by two researchers who analyzed the pre-interviews, while the other two researchers validated the coding-scheme in the analysis of the pre-interview. (Fauskanger et al., 2018).

Teacher´s role 1 in mathematics teaching is to	**Structure in lessons** 2; important to
- find a way to present the content in engaging way 1a - find a way to respond to students thinking, build on it towards the learning goal 1b - be a guide, not lecturer 1c - use resources critically 1d	- have clear learning goals – content goals that teacher has (and can reason for), 2a - have content goals that are represented to students so that they know what is to be learned, but without reducing their thinking 2b - have process goals as" discuss patterns" 2c - have variations in lessons 2d - sum up at the end 2e

Figure 1 Coding scheme, an example of keywords in two of the categories

Using the same coding-scheme as in the pre-interview made it possible to look for changes in how the ISTs interacted with the categories. I started by coding for seven *a priori* categories: 1) teacher's instruction/role, 2) structure in a lesson, 3) differentiation, 4) communication, 5) use of tasks and resources, 6) student engagement and 7) students' learning (Fauskanger et al., 2018). They represent the categories from the study of the pre-interviews (Fauskanger et al., 2018). One utterance could be coded in more than one category. For instance this utterance, "I'm thinking that I almost never, if it is a good task, particularly a problem-solving task (5), feel that I have sufficient time, when we're going to both work on the activity and also put it into words (2)", was coded both in use of tasks – category (5) and in structure of lesson – category (2). The main goal was to look for changes in the use of categories.

After the first coding, not all the utterances fit the categories that were developed in the analysis of the pre-interviews. These utterances were read several times and while reading, emerging ideas were written down. Examples of emerging ideas were the following: teacher knowledge, anticipate student responses and give students the possibility to succeed and develop a classroom discourse where all students can participate. Some of these ideas could fit in the previous categories, for example, the teacher's role and student engagement, but the emphasis was more on teachers' preparation than what takes place in the classroom. For example, the utterance "And of course there is this with the students, that they should experience mastering and all that along the way, and which will create engagement and motivation for the subject" was first coded under student engagement – category (6), but implicitly in this utterance, the teachers take responsibility for giving the students the possibility to succeed. Then this utterance was moved together with the un-coded utterances. This is one example of how teachers talked about their responsibility to enhance their students' learning outcomes, motivate them and give them the possibility to succeed in mathematics. Teachers' planning was a common feature in these utterances and emerged as a new theme. The rest of the utterances that were un-coded were related to how teachers cooperated with parents to obtain a better understanding of how a different way of teaching mathematics would benefit the students.

Findings

Discourses are referred to as ways of interacting using specific words and categories. The analysis in this study has focused on the specific categories the ISTs use in the post-interviews, revealing that the same categories are present in both the pre- and post-interviews. Not really that surprising perhaps, but two new categories emerged: teachers' planning and cooperation with parents. In the post-interviews, the teachers still talked about their role in the instruction, the structure of the lesson, differentiating to meet students' needs, communication in the mathematics classroom between teacher and students, and critical use of tasks and resources. When they talked about student engagement and learning, they conceptualized this as a result of good mathematics teaching. In the following, I will describe the findings in the post-interviews from each category and give examples of representative utterances from the ISTs.

Teacher's instruction/role

In the post-interviews, the ISTs point out that they have to listen to the students and appropriately respond to them so that the students orient themselves towards each other and the mathematical content. For example, one of the ISTs says that he/she "thinks a lot about this, how to address these things they are saying. At any rate where I feel that I'm thinking much more about it. How should you respond to things they say, for example? Don't shut them down, or brush aside solutions even if they are incorrect, but rather address them. And a little bit about what to address to move forward." The analysis shows that the ISTs point out that they need to be facilitators and support the students in facing their challenges and talk about how they can use representations when supporting the students and ask questions to help them make progress without leading the way.

Structure in lessons

The analysis reveals that the ISTs highlight the importance of having a clear goal for the lesson and choosing tasks or activities that support the goal, not the other way around, choosing a task or activity and then deciding the goal for the lesson. This is explained in this utterance: "It doesn't really matter, in that sense, that this activity is better than that activity, rather it's more about why did you in fact choose that activity?" They also talk about structure in the lessons: inquiry-based activities, discussions and summing up at the end of the lesson. One IST summarizes the structure of the lesson in this way: "A good lesson is well considered then, or you have a goal that you want in there, they can set something, the conclusion, that they find a way to phrase, well, representations of their thoughts."

Differentiation

From the analysis, it appears that differentiation is easier for the ISTs when they have activities and problem-solving tasks that give different kinds of students the possibility to join in on each their level. As one IST says: "They have something, everybody has something, they can contribute. Everybody can accomplish something". They still think differentiation is difficult because of the diversity of the students, as seen in how this IST thinks: "Yes, my point is, what I think is difficult, that's to adapt the level in a way."

Communication

The ISTs appreciate when students discuss mathematics with each other. To develop a classroom where students discuss with each other it is necessary to build a positive classroom culture where it is safe for the students to participate. The ISTs point out that talk-moves (Kazemi & Hintz, 2014) have been a useful tool for building a positive classroom culture. They emphasize their role in establishing a community where the students take part in mathematical discussions. As one IST says: "What I am very much focused on is this idea of how to create student activity and conversations between the students and with the students, and the types of questions to be asked, and which I feel are part of the conversation elements."

Use of tasks and resources

Problem-solving tasks are considered helpful for the ISTs as a way of engaging all the students in mathematical thinking, but they mention the importance of tasks that engage students and that are differentiated. One IST put it this way: "When you have a really good task, right, that engages everybody, on all possible levels, so they can work well with it."

Student engagement

The analysis indicates that it is important for the ISTs that the students are motivated and interested. The ISTs describe a good lesson as one where there is a lot of student engagement and the students have a feeling of success. The ISTs also talked about the importance of the students being challenged and the way they addressed this point about their students is revealed by this IST, who says: "It's about mastering, and about experiencing being challenged and accepting that, but also having the faith that you can manage it." Student engagement is seen as being a result of the teacher's actions.

Students' learning

The ISTs point out that the students need to understand basic mathematics, that they learn to learn and can use their knowledge in new situations. This utterance is an example of the idea about the need for students to learn mathematics more deeply. "What I feel is new for me, is this idea about in-depth learning." The ISTs also talk about how they can prepare to enhance their students' learning, as this IST says: "But if you're to be able to guide them on the way, then you, of course, need to have worked your way through the task first and considered possible strategies. If you just grab a random task lying there and hand it out, then there is no guarantee that you will achieve anything."

In the following, I will give examples of the two categories that were new in the post-interview.

Cooperation between parents and school

The analysis reveals that the ISTs experience that parents are critical to the new approach in mathematics teaching or they find it difficult to help their children with their homework. One IST, experienced that parents were critical to her teaching, "Now when we have parent teacher meetings, then I get to hear it, but I have to say that I'm not happy with that there, what was it, one word or another, that she called my teaching, that there is your fantasy teaching, or something like that." Therefore, parents need to be informed about how the ISTs are teaching mathematics.

ISTs' planning

When talking about planning, the ISTs talk about their competence and how they can be prepared to help their students achieve the goal for the lesson. One IST expresses it in this way: "We obviously need some knowledge about the mathematics subject, and to be aware of which goals we want the students to reach and which tasks promote these goals." When planning lessons, anticipating students' responses is suggested as an important point, in addition to planning how they will respond so the students can achieve the goal for the lesson that has been highlighted by the ISTs. One IST relates this to his role as a teacher: "If I had not known anything about possible answers for this task, what can be incorrect answers, and how I can move this to the next level, then I would not have been a good teacher". The ISTs point out the importance of being prepared as part of being a good mathematics teacher and implicitly as part of good mathematics teaching. This kind of planning is time-consuming, but the ISTs think it will be more manageable after working in this way over some time as they will have a base of experiences, as one IST puts it: "We need time then, but perhaps most important is we need time at the start before acquiring a base of experiences from things you have tried."

Discussion and conclusion

The most characteristic finding from studying how ISTs conceptualize good mathematics teaching in the post-interviews is that teacher planning is a part of the ISTs' discourse on good mathematics teaching. This was the most frequent category, and one explanation might be that the ISTs put more emphasis on their planning after they have participated in the MAM project. This indicates that the ISTs put more emphasis on their preparation and put new demands on their knowledge, both in terms of subject matter knowledge and pedagogical content knowledge (Ball & Forzani, 2009). The new demands are expressed in this utterance: "We obviously need some knowledge about the mathematics subject. What we need to keep in mind is which tasks we should present so the students will achieve the goals and be aware of what we want them to accomplish and which tasks will help them do that." This might not be a surprising finding since planning and rehearsal have played an important role in their PD work. Through the co-planning sessions in the PD, they have experienced the complexity of planning a lesson with a specific mathematical goal. This can be related to the learning cycle (Lampert et al., 2013; McDonald et al., 2013) that the PD was built on. In organizing the PD with the learning cycles, co-planning plays an important role, and it might not be surprising that the experiences of co-planning influence how the ISTs conceptualize good mathematics teaching. Through this co-planning they might develop professional communities where productive discussions on teaching and learning can take place (Gibbons, Kazemi, Hintz, & Hartmann, 2017). The content in the learning cycles may also have influenced why this new category has emerged, referring here both to the articles and instructional activities. Throughout the PD work, the participants have discussed the articles and used them when planning, rehearsing, enacting and analyzing the instructional activities. This close connection between theory and practice emphasizes the importance of judgment and action in the classroom (Ball & Forzani, 2011). To be able to make good judgments and choose the right actions in the classroom, you need to be well prepared.

The new category “teacher’s planning” can also tell us something about how teachers position themselves both explicitly and implicitly in the classroom practice. The pre-interviews of these ISTs have indicated that teachers do not emphasize their role in teaching and that there is a shared responsibility between teachers and students for the quality of mathematics teaching (Fauskanger et al., 2018). In the post-interviews, however, the teachers place more emphasis on their role in the classroom and position themselves more centrally in the classroom, giving themselves a more active role. In this way, they are closer to the Finnish teacher educators, where the teacher is described as “a very proactive agent in the classroom” (Hemmi & Ryve, 2015, p. 515). In Fauskanger et al. (2018), the ISTs did not emphasize the teachers’ knowledge, preparation and understanding of textbook content. This has changed after the PD, where they now emphasize planning, their knowledge and the critical use of resources. They are more in line with Chinese teachers, who also emphasize preparation, knowledge and understanding of textbook content (Cai et al., 2009; Li, 2011).

The finding of the new categories in the post-interviews indicates that the PD project has influenced how these ISTs conceptualize good mathematics teaching and that their discourse has changed. Bearing this in mind, it might be anticipated that the PD work also influences these ISTs’ teaching, where they spend more time planning lessons and thinking through how they best can support their students’ learning. Even though there are some changes in how the ISTs conceptualize good mathematics teaching, we cannot say if there is a change and eventually which changes in practice occur. There is reason to believe that the change in how they position themselves will lead to a different dynamic in the classroom (Ball & Forzani, 2011).

This study has only explored the categories teachers interact with in their discourse (Hemmi & Ryve, 2015). In further research, it would be interesting to explore if there is a difference in how they choose their words. Do they use a different language to conceptualize good mathematics teaching? There is also a need to examine how the teachers’ discourse is related to their teaching practice when making decisions about the content they want and how to carry out future PD work. This will be important both for teacher educators and policymakers.

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