## Primary school teachers develop their mathematics teaching

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This ongoing study aims at learning to understand how teachers meet new challenges in their mathematics classes. The research is a qualitative collaborative inquiry into mathematics teaching where seven primary school teachers research their mathematics teaching together with a teacher educator. The results indicate that the teachers are slowly adapting to the processes of reflective practice and studying their own practice.

**Keywords: primary mathematics; community of inquiry; teacher development**

## Introduction

The focus of this ongoing study is on teacher development in mathematics teaching. The main purpose of the study is to deepen our understanding of how teachers meet new cultural and mathematical challenges and how teacher participation in a learning community, with their colleagues and a teacher educator, can lead to changes that are valuable for their work.

In designing the research I draw on my earlier experiences within the field of education both as a teacher and researcher collaborating with general classroom teachers at the primary level. These teachers find it difficult to teach mathematics in diverse classrooms in ways that are coherent with the goals of the national curriculum guidelines in Iceland. Their own experience as mathematics learners was typically as passive receivers who practiced rules and procedures, introduced by teachers and textbooks. They lack experience in investigating, communicating, reasoning and making connections. Additionally they felt incompetent in using these approaches in inclusive schools (Guðjónsdóttir and Kristinsdóttir 2011). If given opportunities to investigate with mathematics collaboratively and solve mathematical problems teachers can discover how the different experiences they bring into the community contribute to their understanding of the mathematics involved and how people learn mathematics (Gunnarsdóttir, Kristinsdóttir and Pálsdóttir 2013).

As a teacher educator I have the desire to identify approaches to teacher education to insure that teachers meet the demand to develop relative to the complexity in mathematics teaching. Drawing from my experience of working with teachers in different kinds of projects I am interested in learning more about the processes that emerge when teachers actively engage in developmental projects and reflect on how they add to their professional knowledge and competences in teaching.

My concerns for all children's opportunities for meaningful mathematics learning have prompted me to work with a group of teachers with the aim of assisting them in reflecting on the learning in their classroom, both their students' learning and their own learning, developed through critical awareness and reflective practice. I contacted two neighbouring schools with diverse groups of students. The teachers had no former experience of researching their own practice but have expressed a desire to develop their own teaching and be better mathematics teachers in these schools. For three years we met at workshops on a monthly basis where we solved mathematical

problems and discussed and reflected on our investigations. We also discussed the teachers' stories from their classrooms and reflected on their students' learning as well as discussing new research on mathematics teaching and learning and teachers' professional development. The focus is on what characterises the learning processes that emerge through collaborative inquiry between classroom teachers and a teacher educator and how the teachers perceive that the participation in the project is reflected in their teaching. The project is goal-oriented as it seeks to build a co-learning partnership between teachers and a researcher with the intention of promoting classroom inquiry in the teachers' classrooms.

## Researching mathematics teaching

The study builds on my former research on teacher reflective practices and development in mathematics teaching when reflection becomes a part of their daily work (Kristinsdóttir 2010). Cochran-Smith and Lytle (2009) emphasize the importance of teacher initiatives in research and in their work. Practitioners are intellectuals who constantly theorise practice as a part of practice itself and the goal of teacher learning initiatives is the joint construction of local knowledge, the questioning of common assumptions, and thoughtful critique of the usefulness of research generated by others both inside and outside contexts of practice.

Professional development for teachers includes pedagogical activities that have practical focus, where dissemination may be presented as examples of good practice. Pedagogical research has a more theoretical focus and is a more formal inquiry with accepted research methodology. The former aims at generating practical information that teachers may find useful in their daily practice. The latter aims at generating theories that may work within schools but are not likely to have effects on school culture if they are not presented to teachers in a way that is accessible to them (Norton 2009). My goal in researching together with teachers is to build a bridge between theory on mathematics teaching and learning and the practice within schools where teachers are engaged with working with children and may neither have time nor interest in reading theoretical papers where results from pedagogical research are presented.

Boaler (2002) has found the notion of mathematical identity to be useful in her analyses of learning. This is the idea that students develop relationships with their knowledge. The idea of identity builds directly from studies of practice and students develop identities through the practices with which they engage. A focus on mathematical practices in classrooms helps researchers and teacher researchers to understand the identities students develop, and the different ways they know and use mathematics (Boaler 2002). The teachers' focus on their students' development of identities and their co-learning in the classroom is an important component in their own development as teachers.

Mathematics educators emphasize the importance of teacher research into their own teaching. Stiegler and Hiebert (2004) claim that teachers play a central role in building a useful knowledge base for their profession. They need to analyse what happens when they try something new in their own teaching and record what they are learning and share that knowledge with their colleagues. Artigue (2009) stresses the importance for research within schools to take into account factors internal to the development of the field itself. The progression of research has made more and more evident that research methodologies have to organize a relationship with the situational, institutional and cultural dimensions of learning and teaching processes.

Research within schools where teachers are active participants in the research process meet these requirements.

## Researching with teachers in a community of inquiry

This study is a collaborative inquiry into mathematics teaching and learning (Goos, 2004) and the aim is to build a co-learning partnership between teachers and a researcher in promoting classroom inquiry (Jaworski 2006). The research builds on sociocultural theories and collaboration between teachers and an academic researcher with the goal of developing knowledge of teacher development in mathematics teaching. The socio-cultural perspective implies that an important part of it is recognition of tensions and issues and the ways in which the project learns through them. Learning to learn from one's own practice requires active engagement and reflection in communities with others (Wenger 1998). Teachers work in schools, which are their communities of practice and where their learning is situated.

In an attempt to make explicit the "practice" in which teachers and researchers participate when collaborating, Jaworski (2003) suggests shifting from the notion of community of practice to that of "community of inquiry", where teaching is seen as learning-to-develop-learning. In such a community, both teachers and researchers learn about teaching through inquiring into it. Traditionally, teacher education has been seen as a transfer of knowledge from educators to teachers. The educators either transfer knowledge to teachers or work with them on developmental programs. Jaworski (2008) finds the community of inquiry framework helpful in developmental projects where teachers and educators work collaboratively on developmental projects. In her framework teacher knowledge of students and schools are equally important as the educators' knowledge of theory, research and systems and together they produce a shared knowledge. She emphasizes that the knowledge of teachers and teacher educators is deeply related although there are differences in their knowledge both regarding specialist areas, individuals and groups. They are all concerned with the mathematical knowledge of students and seek to know more about how to provide better learning opportunities for students learning mathematics. Both teachers and educators bring knowledge to the enterprise and the educators' knowledge needs to be tested in practical settings, as does the teachers' knowledge.

Jaworski discusses the different roles the teachers and an external educator and researcher take. The teachers are the insiders because the research is focused on their practices. "Insider research involves research by teachers into their own teaching. Individual research can take place, fruitfully, in a collaborative environment involving teachers either within a school or across a number of schools" (Jaworski, 2003, 259). The outsiders may take various roles. They can help provide community of teachers and educators where the teachers can share their research practices and discuss their ideas. They may themselves conduct research into classroom learning or teaching and be engaged in research into the collaborative programme. They might also be researching their own practices as educators in supporting teacher research in which case they become insiders in researching their own practice.

Throughout the project I have constantly reminded me on these different roles being an outsider to the teachers' group but with the intention to build a co-learning partnership and in that sense become an insider into the project. My role as a facilitator within the project challenges me to lift the learning relationship between the participants to higher levels of critical thought and dialogue than would be possible within a community of teachers where there is no expert from outside.

## Developing as professionals

For three years we met on monthly bases at workshops lasting one and a half hours. The workshops were videotaped and the teachers collected data from their mathematics classes as well as mutual visits to each other classrooms. Interviews with teachers were audiotaped and notes kept from visits to their classrooms. The focus of the workshops was reflection on mathematics and mathematics teaching and learning. To help the teachers develop their own understanding of mathematics we worked with problems that have the potential to promote mathematical activity and thinking and stimulate collaboration where discussions and sharing thinking is meaningful (Jaworski 2007). To assist the teachers with reflecting on their work I introduced them to a tool for case and commentary writing to stimulate their inquiry and analysis on challenges and dilemmas of their practices (Kruger and Cherednichenko 2006).

Through our collaboration I have seen the teachers develop as mathematics teachers and their awareness of their students learning has grown. They were hesitant to use some of the tools I proposed as an aid for developing their practice. As a response to that I supported them in finding their own ways of developing their practice. At the outset of our collaboration all of the teachers were eager to work on mathematical problems and develop their own way of understanding mathematics. They found it helpful to discuss their thinking about the problems and often related to how their pupils might solve the problems and what they would learn by solving similar problems.

> I learn so much when we work on mathematical problems together. The way you discuss with us and probe for further reflections on the problems helps me to plan my teaching and discuss mathematics with my pupils. (Dóra, April 2010)

Our discussion of how people think differently when they solve problems and that this also applies to their pupils opened up for respecting individual children's thinking. When I first visited Rúna in her special-ed class she carefully explained to her pupils the procedures to carry out when calculating the problems they were supposed to work on. During the class she then assisted them in writing their solutions neatly and carrying out the processes in the prescribed order. At the end of the first year of the project she reflected on her development within the project.

> I have noticed that one of the boys likes to calculate mentally and he is surprisingly good at it. I think I would not have noticed this if I had not participated in the workshops. He does not like to write down his calculations. Of course he needs to learn to do that. Rúna, June 2010

The teachers were hesitant to begin with to discuss their work in their mathematics classes and found it hard to write down cases from their classrooms and bring to our workshop.

> Where will these data be stored and who will read them? As a professional I do reflect on my teaching every day and constantly ask myself how to respond to individual students. Gróa, March 2010

Gróa has deep concern for her pupils and does not give any personal information about individual children to people outside the school. She also expressed clearly from the beginning that she did not want any recording from her classroom. As a response to her concern we discussed the purpose of our collaboration and that we needed to respect each other's confidence in sharing information about our work. I urged the teachers to keep their writing for themselves and told them that they did not need to share them with anyone else if they were not willing to.

During the first year of our collaboration the focus of the workshops was mainly on the teachers' own development of mathematical thinking and on peoples' different ways of understanding mathematics. As the project developed the teachers brought more cases from their classrooms into our workshops and gradually the focus of the workshops changed as discussions on their pupils work with the mathematics took over. At the end of year two Pála told us about her discussion with a girl in her 6th grade class. On a written test the children were to solve the following problem:

      a)  ⅓ of 12              b) ⅕ of 30

The girl wrote the solutions 11⅔ and 29⅘. Pála deemed her solutions wrong and the girl was disappointed as she found her answer to be true.

Pála was concerned about her response. Should she respect the girls' solution? Why did the girl solve the problem this way? The girl read from the instructions that she was supposed to subtract ⅓ of a whole from 12 and consequently the same for ⅕ and 30. Through her discussions with the girl Pála realized that the cause to her understanding of the instructions might be that the problem was badly framed and the instructions misleading. Pála's story aroused intensive discussion about tests and how we grade our students. Pála decided to discuss her grading with the girl and later she told us that they had agreed that her solution was graded as true.

Visiting the teachers' classrooms at the outset of the project I found that most of the lessons started with review of homework; then the teachers described what the subject for the lesson was and explained procedures for solving the problem types on the agenda. The students then worked individually or in small groups with problems in their textbooks and the teachers explained procedures to students that asked for help. There was no common discussion during lessons or round up of the topic at the end of lessons. At the final stage of our collaboration I visited the teachers again and found that the atmosphere in their classrooms had changed and there was more discussion going on in their classrooms about mathematics. The students were working on projects or problems that urged them to think creatively and discuss their thinking. The teachers participated in their work and probed them to develop their solutions further. It was evident that these pupils were used to discuss their thinking about mathematics and were confident with their work as opposed to the pupils I saw three years earlier that relied heavily on the teacher's confirmation of their solutions.

**Conclusions**

At the initial stage of the project the teachers found it important to work with mathematical problems and develop their own understanding of mathematics. However they found it difficult to discuss their classroom experiences. As their confidence in discussing their own mathematical understanding grew they slowly started to discuss their pupils' learning and how their mathematical understanding developed. The results indicate that the teachers are slowly adapting to the processes of reflective practice and studying their own practice. Exploring in different ways with mathematics at the workshops has helped them to look at their pupils' mathematics learning in a new way. Systematic reflection on mathematical interactions that focus on student's learning and understanding of processes, as well as on one's own interaction behaviour, represents an essential professional competence of teachers (Mason 2002).

Gradually I have learned that what the teachers gain from is to be given access to information that they can themselves reflect on and decide how to use in their work. They also need to have opportunity to reflect on their work with the children

and on their own mathematical competence. The tools for investigating with mathematics and reflecting on stories from the teachers' classrooms serve as means for teachers for organizing their own thinking and behaviour.

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