

Professional development in mathematics teacher education

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Icelandic student teachers' professional development starts at the onset of their initial teacher education. We have studied our teaching as teacher educators with a focus on the development of learning communities and reflective practices that are considered important elements of effective professional development. Our studies have given us some guidelines to work with and strengthened our beliefs on the importance of collaboration and discussions.

Keywords: teacher education; learning-community; professional development

Introduction

Professional development is an important part of teacher education for both student teachers and teacher educators. Professional development is a life long process. In our teacher educational program the student teachers are supposed to develop their professional theory from the onset of their studies and are introduced to various ways to develop professionally. Teacher education for compulsory schools (6–16 year old students) in Iceland has in recent years been undergoing radical changes. It has changed from being a three-year bachelor program to a more research based five-year master degree (300 credits). Student teachers who want to become mathematics teachers take a 120-credit specialisation in mathematics and mathematics education both at bachelors and masters level.

The authors of this paper have taught different mathematics education courses for more than 20 years and have taken part in developing the teacher education program in cooperation with colleagues. During this period of change we have studied our teaching as teacher educators with focus on the development of learning communities and reflective practices (Guðjónsdóttir and Kristinsdóttir 2011; Gunnarsdóttir and Pálsdóttir 2011). In our mathematics education courses students have been introduced to various ways to collaborate and develop professionally. They have used lesson study, collaborative lesson planning and co-teaching. They have also worked on group assignments on important issues in mathematics teaching and learning as well as assignments that challenge them to develop their own professional perspective and identity. Our aim is also to introduce professional learning strategies to our students that they can use when they enter the teaching profession. In this paper we will report on our ongoing research on our teaching and development of the mathematics teacher education program.

Effective professional development

Several researchers have pointed out some principles for effective professional development by synthesizing results from various research and development projects (Borko 2004; Desimone 2009; Loucks-Horsley et al. 2010; Wei et al. 2009)

Wei et al. (2009) define effective professional development as development that leads to improved knowledge and instruction by the teachers and improved student learning. They draw on research from both the US and elsewhere that links student learning to teacher development. They put forward four main principles for designing professional learning:

- Professional development should be intensive, ongoing, and connected to practice.
- Professional development should focus on student learning and address the teaching of specific curriculum content.
- Professional development should align with school improvement priorities and goals.
- Professional development should build strong working relationships among teachers. (Darling-Hammond et al. 2009)

They also indicate that other factors like school-based coaching and mentoring and induction programs for new teachers are important and likely to increase the effectiveness of teachers. Intensive professional development rooted in practice is also most likely to change teaching practices and lead to increased student learning.

According to Loucks-Horsley et al. (2010) effective professional development is designed to address students learning goals and needs. It is driven by images of effective classroom learning and teaching and gives teachers opportunities to develop both their content and pedagogical content knowledge and inquire into their practice. It is research based and implies active learning for teachers in learning communities with their colleagues and other experts. It is a lifelong process, linked to other parts of the school system and should be continuously under evaluation.

Professional learning communities seem to play an important role in supporting teachers in continuously improving their teaching and sustaining their professional learning (Fernandez 2002; Loucks-Horsley et al. 2010). Lesson study is referred to as an example of a professional development strategy that has many of the aspects that characterize effective professional development. Lesson study enhances teachers' knowledge and quality teaching, it develops leadership capacity and the building of professional learning communities (Loucks-Horsley et al. 2010).

According to Desimone (2009) there is a consensus among researchers on the main critical features of professional development that can be linked with changes in teachers practice and knowledge and to some degree in student learning. She points out five main features. These are focus on content, active learning, coherence, duration and collective participation. According to Desimone there is strong evidence that focus on content and how students learn that content, in professional development, can be linked to teacher development and to some extent to student learning. Active learning where teachers engage in various activities like observations, reviewing of student work and discussions is also an important feature. Collective participation and duration are equally important. Teachers need time to work with, reflect on and try out new ideas and they need to do this in a learning community with others dealing with the same issues. The critical features Desimone points out seem to capture the core in principles for effective professional development both Darling-Hammond et al. (2009) and Loucks-Horsley et al. (2010) present. They also have much in common with what Borko et al. (2011) claim to be the shared view of many teacher educators on professional development. According to this view professional development for teachers should be a collective endeavour, it should be about the work of teaching and the learning opportunities should be situated within the teachers practice.

Some examples from our research

In the design of our mathematics education courses we have introduced our student teachers to various ways of collaborating and building learning communities during their studies by:

- giving students good possibilities for developing a professional language and collaboration competency,
- creating opportunities for student teachers to focus on students' mathematical learning,
- introducing to them effective professional learning strategies.

We have developed our ways in teaching based on our studies of our own teaching. In these studies we have gathered data from oral and written assignments, interviews, course materials, recordings of evaluation meetings and our course notes. We analyse and categorise the data by emerging themes and reflect on them together with the intention to improve our practice. We will here give some examples from our studies on lesson study, reflective diaries, and student teachers' reflection on their own learning and on our reflective practice.

Lesson study

In lesson study a group of 15 student teachers planned one lesson in grade 8–10 and the lesson was taught twice. The focus of the data analysis was on how the process affected the student teachers. Four themes emerged from the data; *Professional language, collaborative competence, pupils learning and mathematical content*.

The data shows that the student teachers developed their competencies in using *professional language*. When describing their ideas and asking into each other's ideas they discussed thoroughly and went into depth and therefore needed theoretical concepts both from mathematics and mathematics education. It was also evident that they started to refer to the theories and literature they all had studied to make their ideas clearer and to give them more weight. They made an effort to develop ideas together. The lesson study process requires collaborative competence. The whole group has to discuss and come to a conclusion. The student teachers experienced a learning community when they created a lesson plan together and took joint responsibility for the lesson. They experienced taking decisions and thinking together. Through their practice with lesson study they felt how important conversations were. The student teachers started with discussing the teaching approach and wanted to build a lesson that the pupils would find interesting and fun to participate in. They discussed ideas they thought the pupils would like and ended with making a game. Based on their notes from observing the *pupils learning* in the lesson during the first round of teaching they focused on the flow of the lesson. They discussed and wrote about the connection between teaching and learning. The lesson was taught in 3–4 different schools at a time so the student teachers could also compare and discuss how the lesson developed differently in different schools even though they all had the same teaching plan. They were telling stories about pupils that gained understanding and made some discoveries. When deciding on the *mathematical content* the student teachers chose to work with prime numbers and composite numbers. During the planning process they refined their own understanding of the content. They discussed how prime numbers were related to other content in number theory and other fields of mathematics. They also discussed what it implies to teach prime numbers. The student

teachers found lesson study a positive experience. They were more conscious about how complex mathematics teaching is and the advantages of planning it together.

Reflective diary

In most of our courses one of the assignments is to write a reflective diary. As an example all participants read the book *Connecting Mathematical Ideas* by Boaler and Humphreys (2005). In choosing the books the main concern was that its content was on teaching and learning from both practical and theoretical points of view. The student teachers discussed each chapter of the book in small groups and wrote together a reflective diary based on their discussions. We emphasised that they reflected on the text and connected what they read to their experience from their own learning, studies of theories and teaching practice. Recently we conducted an interview study with five new mathematics teachers. They referred to the reflective diary and the group discussions as an experience that has been helpful to them in their practice. The content of the books became so familiar to them that they often referred to them in their discussions with their colleagues. They have kept the books and brought them with them to their schools. From this study we have learned that the discussion of a text is just as important as the reading.

Student teachers' reflections on their own learning

We urge our students to reflect on their mathematics learning in the teacher education programs as well as their former learning in school. When they study new research on pupils' ways of learning mathematics and different approaches to mathematics teaching they get inspired to teach their pupils in a way that gives all pupils an opportunity for meaningful mathematics learning. Reflecting on their experience as mathematics learners and relating to their studies, three student teachers wrote:

When we went to school the teacher described the procedures for calculating numbers, the traditional algorithm. Then we practiced the algorithms individually. We never worked together or even discussed our procedures. We cannot remember that we ever explored relationships between numbers or used any mathematical models. The focus was on memorizing and rote learning and the problems were without context. (Anna, Hanna & Sigga February 2010)

It seems to be so deeply rooted in our culture that this is the way we learn mathematics that when the student teachers look back this is what they recall. According to their experience Icelandic classrooms seem to resemble classrooms in other western countries as described by Stiegler and Hiebert (1999, 2004).

When asking the student teachers about other things they did at school they remember having played games and explored together into many fields in science, arts and crafts, where they used mathematics as a tool, measured, calculated, transformed, reasoned, etc. but they never thought of this experience as mathematics learning. They remember to have been active learners but stereotypes of mathematics learners as passive receivers are the images they give of their own learning.

In order to help our students develop their understanding of their own way of learning mathematics we emphasise that they reflect on their own thinking while solving mathematical tasks. According to Mason (2009) learning mathematics can be supported by providing opportunities for learners to manipulate familiar objects. The aim is to get a sense of relationships that are instances of important properties such as mathematical concepts and facts. Through doing, talking and attempting to record, they can work towards articulating those concepts and facts. Important things happen

when learners try to reconstruct for themselves, in their own words and in conventional terms, what they are coming to understand. In order to support learning, it helps to sensitise yourself to learners' struggles, and the best way to do this is to challenge yourself mathematically by placing yourself in a similar situation and become a learner again.

Björn one of our student teachers wrote in his final remarks on the end of term reflective assignment:

Finally I want to add that this assignment has been very helpful. It is important to take time to think what one has been doing during the winter. I have discovered things about myself, that I of course had some vague ideas about, but are important to write down because then they somehow become more real. What I have discussed here does not only relate to my mathematics learning but gives a good picture of me as a person. Therefore my reflection on my way of studying mathematics has helped me to understand my way of learning not only mathematics but in general. (Björn May 2006)

The assignment was individual but Björn was writing about his reflections on learning in a community with his fellow student teachers. Exploring mathematics with others, doing, talking and reflecting together as well as discussing what they had read about research on children's mathematics learning helped him reflect on how mathematics learning gradually became meaningful to him.

Our professional development

Our collaboration has helped us see from a broad range of views how our student teachers are learning, and in so doing we believe that we have managed to respond to them in a more professional way. By discussing our responses to them and helping each other understand their learning we have opened up a forum and encouraged them to critically reflect on their classroom practice in the light of research. By giving the student teachers access to research on children's mathematical development, their capacity to evaluate students' learning, through analysis of their engagement in authentic mathematical problems, has been enhanced. We have experienced that when the student teachers investigate mathematics their confidence in solving problems increases. Additionally, their understanding of how pupils use diverse ways to solve mathematical problems expands.

The transformation from theory to practice does not proceed automatically. Teacher educators can create learning communities for student teachers and should be responsible for supporting them in teaching mathematics in inclusive schools. As teacher educators we have the desire to identify approaches to teacher education to ensure that teachers meet the demand to develop relative to the complexity in mathematics teaching.

The complexity of teaching about teaching is embedded in the nature of teaching itself and demands a sophisticated understanding of practice (Loughran 2007). In analysing the development of our own teaching we have found that theories and research findings have affected our ways of thinking about mathematics teaching and learning. We have found it rewarding to build our work on research in mathematics education. Gradually we have realized how important it is for teacher educators to understand that pedagogy of teacher education must go beyond the transmission of information about teaching. Student teachers need not only to concentrate on learning what is being taught, but also the way in which that teaching is conducted. Teaching is a complex process that cannot be learned once and for all and it is important in teacher education to open the doors to research in the field.

Writing about our research enhances our understanding of how our collaboration has grown to develop a community of inquiry where we reflect on our work together. It has also affected the learning community that we have developed along with the student teachers.

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