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Collaborative research in in-service teacher professional development

Jónína Vala Kristinsdóttir

University of Iceland, School of Education, joninav@hi.is

Teachers in Iceland are faced with challenges to differentiate teaching as they implement a policy of inclusive education. This collaborative inquiry into teaching of mathematics aims at learning to understand how teachers develop their mathematics teaching through participating in a developmental research. Seven primary teachers worked at improving their mathematics teaching and researched their practice together with a teacher educator for three years. Narrative inquiry was used as an analytical tool to study the teachers' learning. In this paper the focus is on one of the teachers and her learning from participating in the project. The results indicate that she gained confidence in teaching mathematics in diverse classrooms while participating in workshops and that collaborative research can support teachers in developing their practice when meeting new challenges in their work.

Keywords: *In-service teacher education, developmental research, collaborative inquiry.*

Introduction

This paper reports on findings from a three-year qualitative collaborative inquiry into mathematics teaching and learning with the purpose of deepening our understanding of how teachers meet new challenges in their classrooms. The aim was to learn about the processes that emerge through collaborative inquiry between classroom teachers and a teacher educator. In this paper the focus is on one of the teachers', Pála, and her development in teaching mathematics while participating in the project. The research question that will be answered is:

In what way did Pála affect the learning developed within the project and how is her participation reflected in her mathematics teaching?

The study built on earlier research on teacher development in mathematics teaching in Iceland that revealed that teachers take a passive role in their mathematics teaching and lack experience in creating meaningful learning environments for all children (Guðjónsdóttir, & Kristinsdóttir, 2011; Savola, 2010). They have particularly focused on instrumental understanding as opposed to relational understanding (Skemp, 1976) and emphasised that their pupils learn to carry out the steps of the 'traditional' algorithm (Fosnot & Dolk, 2005). My fellow teacher educators and I have found that if teachers are given opportunities to collaboratively investigate 'with' mathematics and solve mathematical problems, they discover how the different experiences they bring into the community can contribute to their own understanding of the mathematics involved, as well as how individuals learn mathematics (Guðjónsdóttir & Kristinsdóttir, 2011; Gunnarsdóttir, Kristinsdóttir, & Pálsdóttir, 2013). In our work with pre- and in-service teachers, we found that they must be offered opportunities to experience learning that enhances inclusive education. Our results correspond with those of Bredcamp (2004) and Moore (2005), who emphasised that if teachers' work is expected to be aimed at diversity and mutual understanding, they require the opportunity to develop and enhance their knowledge about teaching and learning in an environment that reflects the very same aspects that they are expected to foster in their own classrooms.

Teacher development in inclusive settings

Teaching children mathematics requires teachers to understand how their students learn mathematics and they need to be skilled both in mathematics and pedagogy as well as the knowledge that combines knowing about teaching and knowing about mathematics. In recent years the Nordic countries have emphasized mathematical competences of which eight specific mathematical competences were identified. These form two clusters; the ability to ask and answer questions in and with mathematics; and the ability to deal with mathematical language and tools (Niss & Højgård, 2011). Niss & Højgård also outlined a model for mathematics teacher competency where the ability to develop one's competency as a mathematics teacher as well as the competencies of working with students and others towards professional development were identified. It is important to note that development of teaching in classrooms is dependent both on the teachers' knowledge and their ability to learn together with others, both their students and colleagues.

Attention and awareness are important features of mathematics learning. Mason, (1998) holds that teaching is fundamentally about attention and teachers can enhance pupils' attention by attending to their own awareness. When someone else points something out to us our awareness changes slightly; we become more explicitly aware of some features, and less aware of others. Thus in collaborating with colleagues, teachers are afforded the ideal conditions in which work on their own awareness, which can provide conditions for their students to experience them too.

When gaining competence in teaching mathematics teachers build on their knowledge and experience and an essential factor in this process is the participation in learning communities. In order to be able to support learners in their classrooms in acquiring mathematics competence, teachers need to urge their pupils' to ask probing questions, take risks and learn from their mistakes.

In communities of learning the individual learner draws on knowledge in the community as well as on personal knowledge. Nevertheless the main emphasis has been on individualized learning in response to diversity in classrooms. Schools have thus adopted what Ainscow (1995) called integration by making only a limited number of arrangements for including all learners in classroom activities. Askew (2015) argued that learning communities are more inclusive than taking the individual as the starting point for planning learning experiences. In these communities teachers work with the collective construction of mathematical knowledge while still ultimately addressing the needs of the individuals within that community. This is the same position I took in working with teachers, attending to their diverse needs for improving their teaching and finding ways to work in inclusive ways with diverse groups of learners.

Through collaborative activity a community learns from the thinking, practices, and development of the individual. Important features of such communities are discussions about the mathematics attended to in the classroom. In the communities learners listen to each other's solutions and think about connections to their solutions while helping each other refine their methods and explanations. When learners participate in mathematical practices in whatever way they can diversity is no longer an obstacle to classroom talk. It is thus being enriched through the diversity of learners' contributions (Askew, 2015).

Methodology and methods

The 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 order to support classroom inquiry (Jaworski, 2006). The methodology of developmental research (Gravemeijer, 1994) and the ‘developmental research cycle’ (Goodchild, 2008) guided the cyclic process of the research.

In an attempt to make explicit the ‘practice’ in which teachers and researchers participate when collaborating, Jaworski (2003) suggested shifting from the notion of community of practice (Wenger, 1998) to that of ‘community of inquiry’, where teaching is seen as learning-to-develop-learning. In such a community, teachers and researchers both learn about teaching through inquiring into it. In this project the vision was that all the participants would learn about teaching mathematics in diverse classrooms.

For three years I worked with seven teachers at 90-minute workshops on monthly basis. They taught 10 to 12 years old pupils in two neighbouring schools, four were homeroom teachers and three were support teachers that joined them in mathematics classes. The focus of the workshops was on reflection on mathematics, and on mathematics teaching and learning. To help the teachers develop their own understanding of mathematics, we worked with problems that had the potential to promote mathematical activity and thinking as well as to stimulate collaboration where discussions and sharing thinking were meaningful. We also discussed new research on mathematics education and stories from the teachers’ classrooms, reflected on their pupils’ mathematics learning and considered how their mathematical thinking developed. To learn about the teachers’ visions for the project and the cultures in their mathematics classrooms I interviewed them and observed their classrooms at the outset of the project, after the first year, and one year after the last workshop. Data was collected of videotapes from workshops, audiotapes from interviews and notes from classroom observations.

Narrative inquiry was used as an analytical tool to study the teachers’ learning in participating in this project. It is a way of understanding and researching experience through collaboration between a researcher and participants and to research with practitioners their lived experience as a source of their knowledge and understanding (Clandinin, 2013). The stories the teachers told about their work, at the workshops and in interviews, are the basis of the narrative inquiry. The teachers read the drafts of their narratives and commented on them, and then on the final version.

Findings

Pála had been a general classroom teacher over 30 years in grades 5-7 when she participated in the collaborative project. In her teacher education her focus was on language skills and she had attended many in-service courses about language teaching but only a few about mathematics teaching. As a classroom teacher she taught mathematics to 10-12 year old children.

Emphasis on instrumental understanding

When I observed Pála’s classroom at the outset of the study her emphasis on carefully describing the steps of algorithms was dominant. She started the lesson by reviewing homework and then

discussed the content of the lesson. She described carefully to her pupils how to work through the problems in their textbook that she wanted them to solve.

Pála worked closely together with her colleague Dóra, at teaching pupils in their 5th grade classrooms. At our first workshop Dóra wanted to discuss the teaching of ‘traditional’ algorithms (Fosnot & Dolk, 2005). She had discussed the algorithm of long division with Pála and questioned her belief that is necessary for their pupils to learn the steps of the algorithm. Pála added:

What we have been reflecting on is, is it bad, does it spoil anything for them? Does it destroy their thinking process, does it stop anything?

Pála was eager to learn more about how to teach children to calculate. She had emphasised the memorising of facts and at her school children were regularly tested on multiplication facts. Dóra had also questioned this tradition and Pála was starting to review her beliefs about instrumental understanding (Skemp, 1976).

Reviewing her own way of calculating

Pála was eager from the beginning to improve her own way of solving mathematical tasks. When we at our forth workshop discussed how many cans there were needed to build a ten storey tower of cans she said:

There would be 10 here [points to the bottom row of the 10 storey tower she drew]. Then I would count 9 and 1, 8 and 2, 7 and 3, 6 and 4. Then I have 10, 20, 30, 40, 50 and then add these 5 [points to her drawing for each step] and have got 55. I do this to be quick at counting.

Pála was reflecting on her own way of calculating when she said that she did this to be quick at calculating thus attending to her own awareness of learning (Mason, 1998).

As the project developed Pála brought in problems she had been solving with her pupils and wanted to discuss her understanding of the problems with us. At Workshop 15 she told us about her discussions with her pupils about how many handshakes there would be in their class if they all shook hands with each other. The children decided to try this and were quick to realise that they would only shake hands once with each person. They developed a rule that could be used to calculate the handshakes in their group of 15 pupils: $14+13+12+ \dots +2+1$. They then split into smaller groups to test if their rule could be applied to a group of any size. Pála had not thought about the solution of this problem before it was discussed in her class and therefore took an active part in the solution process. By comparing the total handshakes for different number of pupils, they then had developed a formula together. Pála was keen to discuss with us whether the formula $n(n-1)/2$ could be applied to calculate the handshakes for a group of any size. Pála said:

I do not understand why this equation works, why this connection. I know it works, we have tried it for many cases. Can you help me to understand why it works? I would like to proceed to work with the children in this way.

By asking us to discuss her experience with us Pála was adding to her competence of learning together with colleagues and in discussing with her pupils she was developing her competence in learning with them. She was also supporting her pupils in developing their the ability to ask and answer questions in and with mathematics (Niss & Højgård, 2011).

I reminded Pála on her earlier addition of consecutive numbers in relation to the tower of cans. Pála said that she remembered it but she still could not understand why the formula she had developed with her pupils worked. We then discussed their formula and why it could be used to calculate the handshakes and in doing so we were inquiring into our own mathematics learning (Goos, 2004) and cultivating our learning community (Jaworski, 2003). I pointed out that she took an active part in the learning process in the classroom. Not only did she learn about the children's thinking but also about her own thinking about the problem. She had given them a problem that neither she nor they knew beforehand how to approach. Then they all started to investigate and look for patterns and developed a rule together. Through these discussions our co-learning partnership was cultivated as we focused on classroom inquiry (Jaworski, 2006).

Learning together with her pupils

Pála was starting to learn together with her pupils by exploring with them in the classroom as opposed to the beginning of our collaboration when she had carefully explained to her pupils, how to solve problems. At our final workshop she shared with us her discussions with her pupils. They had worked with different kinds of word-problems in their textbook. They were required to write their solutions to the problems with algebraic expressions. She gave examples of the pupils' discussions about the problems and how they wrote the expressions. She had recorded these examples in her notebook and now wrote on the whiteboard to show us how the pupils calculated and how she interpreted their thinking about the problems.

We discussed two of the problems:

Klara is 4 years younger than her brother Kári. Their total age is 18 years. How old is Kári?

A large apple costs 11 ISK more than a small apple. The total price of a small apple and a large apple is 59 ISK. What is the price of a large apple?

Pála had solved the problems herself and her thinking was different from her pupils' but they all came to the same conclusions. She wanted to discuss this experience with us and hear my interpretation of the different ways they solved the problems. She was particularly keen to hear my opinion with regard to the way she had accepted her pupils' way of solving a problem instead of telling them to think about it in the same terms she did.

Jónína: Pála, you said that the children wrote $x+x+4=18$ and you wrote $x+x-4=18$.

Pála: Yes. And for the apples they wrote $x+x+11=59$ and I wrote $x+x-11=59$.

We discussed how the value of the unknown variable in Pála's equation was different from the value in the children's equation. Still in both cases they came to the same conclusion about the age of the siblings and the price of the apples. Pála said that all the children in her class were able to solve the word problems by first trying some numbers and then adjusting them until they found the right numbers. Many of them could write the equations and they then supported each other in doing so. Finally Pála concluded: "These were just my thoughts. I found it interesting to see how they understood and thought about this".

When Pála shared this story with us she was cultivating our learning community (Askew, 2015; Jaworski, 2006). But she had also attended to her pupils' way of learning and was now focusing on their way of expressing themselves instead of describing carefully to them the steps they needed to

take as she did to begin with thus making herself aware of her pupils diverse ways of learning (Mason, 1998).

Grouping pupils into ability groups

In Pála's school it had been the custom for many years to group children into groups in mathematics classes based on the outcomes of an end of term test. When the project began Pála and Dóra had divided the 43 children in fifth grade into three groups in mathematics classes. A special education teacher taught the pupils who got the lowest grades, Dóra taught those who got the highest grades and Pála taught the middle group. With this arrangement they were responding to diversity by making only a limited number of arrangements for including all learners in classroom activities (Ainscow, 1995). To begin with Pála was concerned that the pupils in her group were not capable of solving problems without her leading them step by step. Gradually as she became more confident with exploring with mathematical problems herself she started to listen to them and allow herself to join them in their explorations with problems as discussed above.

When Pála shared her experiences of working with her pupils with us we discussed how her approach supported the children's learning like the case with the handshake problem. She told us that some of her pupils understood why the formula could be applied to solve this problem and others did not. They though all understood that they could calculate the total number of handshakes by adding $(n-1) + \dots + 1$. We then related to our former discussions of tasks that can be solved at many levels and are therefore suitable to work with in diverse classrooms. Pála was satisfied with this experience and found that she was beginning to trust that all her pupils were capable of more in-depth learning than she had realized before thus acknowledging that diversity is no longer an obstacle (Ainscow, 1995; Askew, 2015).

The final year the project was running Pála and her close colleague, Dóra, had decided not to group their pupils into ability groups any more. They had become confident in investigating in mathematics with their pupils and found that all the children in their classes were capable of learning together and gained from sharing experiences with each other.

Professional development and influence on our project

Pála took an active part in using the tools for professional development that I offered the teachers in our learning community. She visited her colleague's classrooms and discussed with them what they learned from their visits and she recorded her lessons to learn from her communication with her pupils. She also shared her experience from her learning in the classroom with us and gradually started to lead what to focus on at our workshops. Not only did she share this experience with us she also brought in problems she had found elsewhere and asked us to solve them with her.

The project was only planned for one year to begin with. As we approached the end Pála expressed her wish to meet for a second year. She felt that she and the other teachers were just starting to develop their teaching and could not stop when they felt that they were gaining so much from our collaboration. The other teachers agreed with her and our project ran for three years as the teachers wished to extend it for the third year. With her willingness to share her thinking with us and take lead in what to focus on at the workshops Pála shaped the developmental process of the project and affected the 'developmental research cycle' (Goodchild, 2008).

Conclusions

Based on the narratives of Pála's participation in the collaborative project I have concluded that she gained confidence in teaching mathematics in diverse classrooms and that collaborative research can support teachers in developing their practice when meeting new challenges in their work. The sketches from our collaboration are representative for the learning that emerged during our collaboration. In the communities of inquiry we managed to build at the workshops we supported each other in learning-to-develop-learning (Jaworski, 2003) by reflecting collectively on the stories the teachers told of their classroom experiences. From the stories Pála told us we learned how her pupils' competences in dealing with mathematical language and tools were developing as well as their ability to learn about their own learning in working with their pupils (Niss & Højgård, 2011).

By offering the teachers opportunities to experience learning that enhances inclusive education (Bredcamp, 2004; Moore, 2005), the teachers were empowered to develop their teaching as was reflected in Pála's learning.

During our three years of collaboration I, as a teacher educator and a researcher learned about teachers' capabilities to develop their own teaching if they are supported in reflecting on their learning of mathematics as well as their pupils' learning. In reflecting on their learning about mathematics teaching my understanding has deepened of the opportunities and challenges teachers meet when including all learners in meaningful mathematics learning.

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