Adopting the developmental research cycle in working with teachers

Jónína Vala Kristinsdóttir
University of Iceland – School of Education, Iceland

This collaborative inquiry aims at learning to understand how teachers in schools and a mathematics teacher educator develop their work through participating in a developmental research project. Seven primary teachers worked at improving their mathematics teaching and researched their practice together with a teacher educator for three years. A model of a developmental research cycle, with two interconnected cycles of development and research, was used as the framework for the research. The main findings are that partnership between teachers in schools and teacher educators, where the knowledge both parties bring into the project is mutually respected, can add to our understanding of teacher development.

Introduction

Over the last two decades Icelandic teachers have been under growing pressure to adapt their work to changes in new curriculum guidelines and laws for schools. Teachers are now expected to meet the needs of diverse groups of children and improve their teaching competence. This paper reports on findings from a developmental study in which seven teachers in primary grades and a mathematics teacher educator collaborated. The aim was to investigate how the teachers and the teacher educator collaborated in researching their own practice, and the ways in which this collaboration impacted the work of both parties. The goal was to identify approaches to teacher education that could support teachers in meeting the needs of diverse learners in the mathematics classroom.

In former work with teachers I had found that many teachers lacked confidence in teaching mathematics in diverse classrooms. They lacked experience of focusing on mathematical processes and felt incompetent in using these approaches in inclusive schools (Guðjónsdóttir & Kristinsdóttir, 2011). In inclusive schools, emphasis is placed on the perspective that everyone is respected and noticed, their participation is valued, and an opportunity is created for them to achieve and show their strengths (Ainscow & Miles, 2008).

I decided to work with a group of teachers with the aim of assisting them in reflecting on the mathematics learning in their classrooms. The reflection should concern both their students' learning and their own learning, with regard to which I encouraged critical reflection. I contacted two schools with diverse groups of

students. The study thus involved a) seven primary school teachers in grades 5-7 who examined their own practice as mathematics teachers, with my support and b) myself, where I focused on the collaborative process itself, as a whole, as well as the development I underwent throughout the research process, as a teacher and a researcher. Over a period of three years, we met at workshops on a monthly basis (17 in total) where we solved mathematical problems and discussed and reflected on our collaborative investigations. We also discussed the teachers' stories from their classrooms and reflected on their students' learning, as well as discussing how their experiences reflected findings from other research on mathematics teaching and learning and on teachers' professional development.

The focus here is on the processes that emerged throughout the project and the use of the developmental research cycle in answering the question: What learning processes emerge through long-term collaborative inquiry undertaken by classroom teachers and a mathematics teacher educator? The study involves a process through which teachers research their own practice with my support and myself researching this collaborative process and my development as a researcher.

Methodology

A model of a developmental research cycle as put forth by Goodchild (2008) was used as the framework for the research. In this model there are two interconnected cycles of development and research that model a linked dialectical growth of theory and practice. The model is based on Gravemeijer's (1994) description of developmental research, though with particular emphasis on the cyclical process between development and research. This diagram is presented in Figure 1.
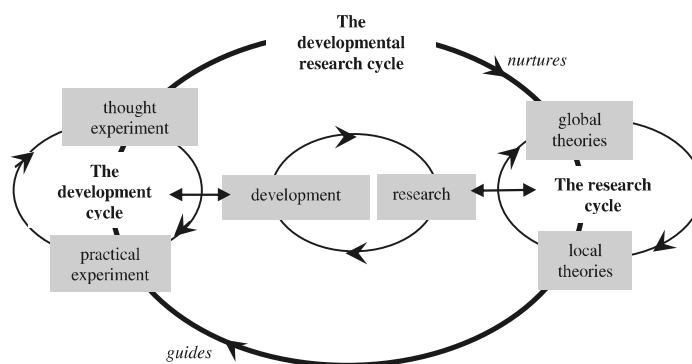

Figure 1: The developmental research cycle (Goodchild, 2008, p. 208)

The developmental research cycle represents two interconnected cycles that model the dialectical growth of both theory and practice. Components of the developmental cycle are presented as a thought experiment to accompany a practical experiment. The research cycle moves between global theories that are

concretised in local theories. The cycles are interrelated; local theories are tried out in practice, when thinking through the consequences of some action and then implementing it in harmony with conclusions from the planning process. This leads to the adjustment and analysis of the local theory that informed the action, which then in turn, results in a reconstruction of the global theory. Consequently, the research cycle guides the development cycle, which in turn nurtures the research cycle (Goodchild, 2008; 2014).

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 17 workshops, audiotapes from interviews and notes from classroom observations. The analysis of the results started at the outset of the study as a spiral of analysis developed over time (Creswell; 2007). The results from the analysis guided the process of the study as they were used to resolve what to focus on at each phase of the project.

Theoretical framework
The local theories that guide the study are based on former findings from research with colleagues where we found that teachers need support in reflecting on their students' learning of mathematics as well as on their own way of mathematics learning (Guðjónsdóttir & Kristinsdóttir, 2011).

The global theories that guide the study are sociocultural, in the Vygotskian sense, that individual cognition develops when people change their ways of understanding, perceiving, noticing and thinking through shared efforts with others (Vygotsky, 1978). During this development, they build on the cultural practices and traditions of communities such that participation is seen as both a social process and a personal experience (Lave & Wenger, 1991). When developing learning communities where the diverse background of the participants is respected, everyone's contributions must be valued. Jaworski (2006) argues that collective learning develops through a mutually reflexive process of knowledge growth between individuals and a community in which co-learning partnership is cultivated. Thus, through the process of sharing experiences and developing norms, the community provides supportive structures for individual inquiry and acts to mediate knowledge so that knowledge grows within the community, as well as for each individual.

Askew (2015) argues that in order to foster an inclusive approach in attending to diverse learners needs, it is important to begin with learning communities, rather than taking the individual as the starting point for planning learning experiences. In the learning 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 position I took in working with teachers when attending to their different needs for improving their teaching.

Reflecting on and in one's own practice is an essential feature of teacher development and in inquiring into one's teaching. Inquiry refers to critical reflection and can be seen as a mode for critically reflecting on mathematics learning, mathematics teaching and research into the teaching of mathematics. Jaworski (2008) argues that in a community of inquiry the inquiry is seen both as a tool for developing practice and as a way of being in practice, and thus, inquiry becomes a norm of a community of practice. When individuals are encouraged to look critically at their own practices and to modify these through their own learning-in-practice, there will be a shift from "community of practice" to "community of inquiry". Through the shift a perspective emerges in which reflective development of practice by practitioners, individually or in groups, can be seen to result in the development of community.

The participants in the study belong to different communities, within a complex landscape of learning (Wenger-Trayner & Wenger-Trayner, 2015), that all affect how we interpret the learning that developed within our community and thus our own individual development as mathematics teachers and a teacher educator. The teachers' background and the experience they bring into our community, shape our collaborative work.

The quality of mathematics learning in classrooms depends on the teachers' capability of building communities that enable learners to develop their mathematical competences. To be able to enrich learning in mathematics classrooms, teachers need to be competent in approaching their teaching in such a way that all participants in their classrooms will gain from it. The competency model developed by Niss & Højgaard-Jensen (2002) explaining the ability to develop one's competency as a mathematics teacher was adopted for the project. The development of teaching in classrooms is seen as dependent both on the teachers' knowledge and their ability to learn together with others, both their students and colleagues. The teacher learns from participating with the learners about her own learning and of the collective learning in the classroom that shapes the classroom culture.

Findings

The developmental nature of the study entailed that the structure was flexible. The protocol for each of the workshops was based on the teachers' expectations for what to attend to and they were urged to come up with proposals for activities. I offered them tools to work with, entrusted them to decide what they found helpful and challenged them to rethink their teaching habits by participating in investigations into their practices. A sequence of six themes developed as our co-learning

progressed. The following examples are representative for the learning processes that developed through our long-term collaborative inquiry.

Initial steps to an investigative approach: Based on the local theories and on the teachers' visions for the project our collaboration started with problem solving, discussions on our findings. The teachers' related to experiences from their classrooms. Vala was prompted to tell us about two boys in her group who always write checkmarks or count things at hand when they calculate. Dóra added that her pupils were not always willing to draw. They often said: "I think this in my head".

Edda: But can they explain it? That is often difficult.

Dóra: I know. It is often difficult to tease it out.

Jónína: Why is it difficult? Why is it difficult to explain one's thinking?

Vala: Is it not just a lack of practice?

Reflective practice, hindrances and opportunities: We continued exploring with problems I brought in and the teachers told about their work. I encouraged them to write about what they had noticed in their classrooms and to analyse their findings, based on a protocol for case and commentary writing (Kruger & Cherednichenko, 2006), that I introduced to them. A few days later I received an email from Gróa and two of her colleagues. They wrote that they were sitting together and reflecting on how they could explain their work. They felt, as teachers with wide-ranging experience, they were capable of assessing their work without writing in detail about it.

In my reply, I said that I was aware of the fact that in their work they always reflect on and attend to the needs of individual children. The goal of the task was to urge them to reflect on individual cases and support them in analysing what they have learned about their work. I urged them to write their own notes and keep for themselves. We would continue to discuss our teaching at the workshops.

A focus on interactions in mathematics classrooms: As the project developed we focused more on interactions in mathematics classes both by exploring together at the workshops and by discussing the work in the teachers' classrooms and analysing their cases together. The teachers planned visits to each other classrooms, observed and participated in lessons. They soon discovered that if they planned their visits together and met after them to discuss they gained insights into how to advance interactions in the classroom. Pála said:

Yes, I felt we discussed this, how we grouped the pupils and how we are reflecting on each and everyone's learning. How we can activate them and how we have succeeded.

Many of the pupils in the teachers' classrooms are newcomers and have not mastered the Icelandic language yet. Vala mentioned that they have difficulties in discussing their work but the mathematical symbols help in communicating about their work. Dóra added:

One girl did not understand anything and started crying. Then I talked to her with mathematical symbols. That is how we made contact and developed mutual trust.

The original plan for the project was approaching the end. The teachers felt that they were beginning to develop their practice and proposed to proceed for at least another year.

Focusing on pupils' learning in the classroom: Inga, a special education teacher, was concerned for her pupils' lack of self-esteem in mathematics: "These kids show such little initiative and they are so uncertain of their ability to learn". She was worried that the children who have learning problems are often told that they do things the wrong way and shared her concerns with us:

Instead of getting the chance to explain their thinking, the teachers tend to explain to them again and again in a way that they do not understand. This makes them uncertain about themselves and they want the teacher to tell them what to do. But when the teacher listens to them they feel that they are capable of explaining their thinking like other children.

Teacher reflections lead our discussions: The teachers were taking more responsibility for what to attend to at the workshops. Gróa told about cultural days in her school and how she had decided to work with mathematics when an opportunity presented itself. We discussed and analysed her story.

Jónína: When we as teachers think as you do, reflect on our conditions and then respond to the situations, what are we then doing?

Gróa: What am I doing? … You do not think when you are in the action, you just, you see that something needs to happen.

Jónína: Yes, and why do you do that?

Dóra: So, the pupils will understand.

Gróa: To try to make the pupil understand. Particularly when you see that one pupil understands, and the other does not. What can I do?

Jónína: This is what we are looking into, how professionals work, your response did not come out of the blue. … And this is what teachers do. What I am asking you to do is to look into how you do this. What you reflect on and how it is represented in what you do. How you come to these conclusions, because when you are in the classroom you are not thinking about how you reached the conclusion.

Towards an investigative approach and inclusion: At our final workshop Pála told about a mathematics lesson in which her pupils worked with word-problems. 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, showed us how the pupils calculated and how she interpreted their thinking about the problems.

Pála 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. We discussed how the value of the unknown variable in Pála's equation was different from the value in her pupils' equation and she was confident in accepting their way of writing it.

Pála:	These were just my thoughts. I found it interesting to see how they understood and thought about this.
Jónína:	Yes, and their discussions about what they did.
Pála:	Yes, they discussed a lot. They all enjoyed this and found it easy.
Jónína:	And still this is algebra. … This problem was in the form of a story that the children could visualise. When we teach this in abstract form without context many pupils have difficulties with this abstract form.
Pála:	It is important that the problems are about something, something they know.

Pála's story mirrored a discussion where she inquired into mathematical problems with her pupils and nurtured reflective discussions. In the final visits to the teachers' classrooms and interviews with them I found that they had been strengthened to review their work and taking on an investigative approach in their classrooms and into their own practice. They also had questioned norms at their schools, like testing children on memorising facts and grouping them into ability groups in mathematics classes and taken actions to influence the culture in their schools about these norms.

Discussion

The sequence of six themes developed as we moved between the developmental and research cycles and reflected on the global and local theories we based our research on as we developed our learning community. The mutual trust we built supported the learning process and nurtured our collaborative progress as tensions arouse. The teachers were concerned about their pupils' way of learning mathematics and I challenged them by asking them probing questions to support them in inquiring into their practices (Jaworski, 2008). The first confrontation in our work presented itself when I required the teachers to write about and analyse cases from their classrooms. I realised that I had been too quick to step into the role of a teacher and needed to respect that these teachers are professionals who belong to other communities within their schools (Wenger-Trayner & Wenger-Trayner, 2015). I decided to give space for discussing the cases at the workshops and collectively analyse them. I needed to align myself to the community we were shaping together and respect the teachers' values (Lave & Wenger, 1991).

When we critically reflected on our work the teachers learned how inquiring into their teaching can support them in developing their practice (Jaworski, 2008).

Their reflections prompted them to find ways to include all learners in the mathematics discussions in their classrooms (Askew, 2015). By sharing their work, they developed their competency as mathematics teachers when reflecting on their experience of communicating with their pupils and sharing it with us (Niss & Højgaard-Jensen, 2002). Additionally, they nurtured our learning and added to building our community of practice (Vygotsky, 1978; Lave & Wenger, 1991).

By bringing in a story from cultural days Gróa cultivated our co-learning partnership (Jaworski, 2006). I responded to her story and urged her to critically reflect on her contribution (Jaworski, 2008) and analyse her own learning with our support, thus responding to her reluctance to write about it. Pála's story from her classroom gave an insight into how she had changed her way of teaching as she had gained experience in solving problems together with us and discussing her own thinking. Instead of describing step by step to her pupils how to write algebraic equations, as she had done before, she felt confident in accepting their way of doing it and discuss with them how their thinking about the problem was different from her own. Her story was an indication of that we had succeeded in building a community of inquiry where we reflected on our practice and this experience affected the culture the teachers built in their classrooms (Jaworski, 2008).

The teachers aligned critically to established norms at their schools as they adopted an inquiry stance to their teaching (Jaworski, 2006). The tensions that arouse within our community became a source of creative innovations for the teachers and myself as we learned to question established norms within our professional culture and initiate creative innovations (Goodchild, 2014).

Conclusions

Adopting the developmental research cycle (Goodchild, 2008) was vital in analysing the gradual progress of our community building. The spiral of reflecting on the developmental cycle in reference to the research cycle supported actions taken in our collaborative work. As we learned to accept the knowledge that each of us brought into the community and think of ways to cultivate it, the developmental cycle affected the research cycle. The global socio-cultural theories about co-learning and community building affected the local theories about teachers' need to rethink their own way of exploring with mathematics and work with their pupils. The local theories in turn affected the developmental cycle when we decided what to attend to at the workshops and how to communicate about our work (Goodchild, 2008).

The results of this collaborative inquiry into mathematics teaching and learning showed that partnership between teachers in schools and teacher educators, where the knowledge both parties bring into the project is mutually respected, can add to our understanding of teacher development. In particular when

the aim is to support classroom inquiry where pupils in schools learn mathematics through exploration, as conceptualised in Jaworski (2006). The learning gained from the study aligns with the findings of Askew (2015) about teacher development that aims at inclusive practices and mutual understanding. Teachers need opportunities to develop and enhance their knowledge about teaching and learning in an environment that reflects the very same aspects they are expected to foster in their own classrooms.

The overall results indicate that teachers are professionals who can work at developing their mathematics teaching in order to cultivate inquiry in mathematics within their classrooms when provided with support on discussing and interpreting their work in classrooms. The findings support the view that teachers' opportunities for further empowerment to participate in educational research needs to be facilitated.

References

Ainscow, M., & Miles, S. (2008). Making education for all inclusive: Where next? *Prospects, 38*(1), 15–34.

Askew, M. (2015). Diversity, inclusion and equity in mathematics classrooms: From individual problems to collective possibility. In A. Bishop, H. Tan, & T. N. Barkatsas (Eds.), *Diversity in mathematics education: Towards inclusive practices* (pp. 129–145). Cham: Springer.

Creswell, J. W. (2007). *Qualitative inquiry & research design: Choosing among five approaches.* Thousand Oaks: Sage.

Goodchild, S. (2008). A quest for a 'good research': The mathematics teacher educator as a practitioner researcher in a community of inquiry. In B. Jaworski, & T. Wood (Eds.), *The international handbook of mathematics teacher education. Vol. 4: The mathematics teacher educator as a developing professional* (pp. 201–220). Rotterdam: Sense Publishers.

Goodchild, S. (2014). Mathematics teaching development: learning from developmental research in Norway. *ZDM, 46*(2), 305–316.

Gravemeijer, K. (1994). *Developing realistic mathematics education.* Utrecht: Freudenthal Institute.

Guðjónsdóttir, H., & Kristinsdóttir, J. V. (2011). Team-teaching about mathematics for all: Collaborative self-study. In S. Schuck, & P. Pereira (Eds.), *What counts in teaching mathematics: Adding value to self and content* (pp. 29–43). Dordrecht: Springer.

Jaworski, B. (2006). Theory and practice in mathematics teaching development: Critical inquiry as a mode of learning in teaching. *Journal of Mathematics Teacher Education, 9*(2), 187–211.

Jaworski, B. (2008). Building and sustaining inquiry communities in mathematics teaching development. In K. Krainer, & T. Wood (Eds.), *The international handbook of mathematics teacher education. Vol. 3: Participants in mathematics teacher education* (pp. 309–330). Rotterdam: Sense Publishers.

Kruger, T., & Cherednichenko, B. (2006). Social justice and teacher education: Re-defining the curriculum. *The International Journal of Learning, 12,* 1–8.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge: Cambridge University Press.

Niss, M., & Højgaard-Jensen, T. (Eds.) (2002). *Kompetencer og matematiklæring. Uddannelsesstyrelsens temahæfteserie, 18, 1–334.* Undervisningsministeriet (Ministry of Education), 2002. Retrieved from http://pub.uvm.dk/2002/kom/

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processe*s. (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, eds. and trans.). Cambridge: Harvard University Press.

Wenger-Trayner, E., & Wenger-Trayner, B. (2015). Learning in a landscape of practice: A framework. In E. Wenger-Trayner, M. Fenton-O'Creevy, S. Hutchinsn, C. Kubiak, & B. Wenger-Trayner (Eds.), *Learning in landscapes of practice: Boundaries, identity, and knowledgeability in practice-based learning* (pp. 13–29). London: Routledge.