LEARNING IN AND FROM PRACTICE: PRE-SERVICE TEACHERS INVESTIGATE THEIR MATHEMATICS TEACHING

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This study examines the learning of five pre-service teachers investigating a question stemming from their mathematics teaching as part of a final course project in their elementary teacher education program. Analysis of video recordings of group meetings and interviews indicate that as pre-service teachers completed their projects they developed a relationship with the discipline of mathematics and of teaching mathematics that included the inclination to seek conceptual understanding and pursue a stance of inquiry. This study builds on our understanding of connections between knowledge, practice, and identity and how a teacher education program can offer possibilities for pre-service teachers to negotiate new identities as mathematics teachers who can learn in and from practice.

INTRODUCTION

Many teacher educators and students would agree with Lampert and Ball's (1998) statement that, "overall teacher education has been a weak intervention on the powerful images, understandings, beliefs, and ways of thinking that prospective teachers bring with them from their prior experiences as students" (p. 24). One way of addressing this issue is to consider how teaching practice can be a context for learning to teach mathematics. Ball and Cohen (1999) speak about this in terms of learning *in* and *from* teaching practice. They argue for a broad view of "in practice" to include not just that which occurs in the classroom but all that is critically necessary in the activity of teaching. Practice in this sense is not specific to a particular place, nor to physical actions over mental ones, but instead to the explicit and the tacit activities that teachers have developed in order to teach (Wenger, 1998).

Research on professional development provided to practicing teachers that focuses on helping teachers learn in and from practice includes opportunities for teachers to examine students' thinking (Schorr & Alston, 1999; Vacc, Bowman, & Bright, 2000), reflect on teaching practices (Schifter, 1996), develop or discuss teaching cases (Barnett & Tyson, 1999), or participate in teacher study groups (Stigler and Hiebert, 1999). This research shows promise toward enhancing teachers' understanding of mathematics and pedagogy and how teachers use this knowledge to inform their teaching. However, we know less about how we might support beginning teachers to learn in and from practice. Some recent research focuses on introducing new technologies in mathematics teacher education as a resource for inquiry into practice or on integrating field-based experiences into mathematics curriculum and instruction courses (e.g. Lampert and Ball, 1998; Crespo, 2000; Nicol, 1999). Our study builds on this work to examine the learning that occurs when pre-service elementary teachers are given opportunities to investigate their own mathematics teaching practice.

THEORETICAL CONSIDERATIONS

Wenger (1998) provides a social theory of learning within communities of practice that we find useful for our work. A community of practice, according to Wenger, has coherence through the dimensions of mutual engagement and shared activities, a joint enterprise or shared goals, and a shared repertoire of social and physical resources that can be used to meet the negotiated goals. A community of practice could be, for example, a group of pre-service teachers teaching in the same school who come together to understand their practice. Wenger argues that learning involves the development of identity, the changing of who we are, in the context of the communities of practice that we participate in. He states: "Because learning transforms who we are and what we can do it is an experience of identity. It is not just an accumulation of skills and information, but a process of becoming–to become a certain person or, conversely, to avoid becoming a certain person" (p. 215). Our identities, then, are shaped and formed by our participation or non-participation in various practices which, in turn, shapes our communities of practice. Developing an identity in practice is a constant process of negotiation. "We are always simultaneously dealing with specific situations, participating in the histories of certain practices, and involved in becoming certain persons" (Wenger, 1998, p. 155).

Boaler and Greeno (2000) draw upon the work of Wenger (1998) and others to examine how high school students' knowing of mathematics can be understood as participation in particular social practices. In their interviews with students enrolled in advanced placement calculus courses they found that some were not interested in pursing mathematics as a field of study because the requirements of the social practices in which they participated as mathematics learners were in conflict with the type of person they wanted to be. That is, these researchers found that different classroom practices encourage students to develop different relationships with the discipline of mathematics that profoundly influence their interest in and learning of mathematics (Boaler, 2002).

Ma's (1999) research is helpful in considering teacher's relationships to the discipline of mathematics. In interviews with experienced elementary school teachers in China, Ma found that these teachers had not only developed understandings of fundamental mathematics that were deep, broad, and thorough but also displayed various mathematical attitudes. Chinese teachers sought to "know how to carry out an algorithm and to know why it makes sense mathematically" (Ma, 1999, p. 108). These teachers shared a disposition to ask why and to explore the mathematical reasoning underlying mathematical procedures. They had developed a relationship with the discipline, to use Boaler's (2002) concept, that included the expectation that claims be justified with mathematical arguments and that problems be approached in multiple ways. They saw themselves as participating in a teaching practice that required not only strong procedural and conceptual understandings of mathematics but also the need, ability, and importance of conveying these understandings to students. Chinese teachers developed this relationship through teaching in a community of practice that valued and expected their participation in certain practices such as examining curriculum materials, working with colleagues, learning mathematics from students, and doing mathematics themselves. An important aspect of this research and of Boaler (2002) and Wenger's (1998) is that it

brings together learning, practice, and identity. It highlights how social practices, disposition and identity influence what teachers know, how they know it, and how they share their understandings with students. Our research builds on this work as we explore how we might design instructional environments that help beginning teachers develop a relationship to the discipline of mathematics and to the practices of teaching that enables them to learn in and from practice.

RESEARCH CONTEXT AND DESIGN

The Context

The context for this study is a Problem-Based Learning [PBL] cohort in a 12-month elementary education program for post-baccalaureate students at the University of British Columbia. Following the philosophy of problem based learning, students work in a small groups with a tutor to examine cases of teaching and learning. A final assignment for PBL students toward the end of their program is to construct and respond to their own written case of teaching and learning. This study focuses on a small group of PBL students who were invited to use their teaching practice as a context for their final case project and were provided with opportunities and support to use new technologies as a resource to do this.

Participants

This paper focuses on the experiences of five pre-service teachers in the 2001 -2002 PBL cohort who chose to explore a question related to mathematics teaching for their final case project. Participants were female ranging in age from mid 20's to early 30's. During their 13-week extended teaching practicum they met regularly, about every two weeks, as a group to discuss their teaching and the kinds of issues or problems they considered researching as part of their final case project. They were given access to laptop computers and digital video cameras so that they could collect and edit video clips of their teaching, interview pupils and teachers, and document student work. During the group meetings students used the technology not only to develop aspects of their final case projects but to also share teaching episodes or pupil's thinking in order to collectively help each other interpret and make sense of their teaching. After the practicum pre-service teachers were given three weeks to produce and respond to a case of teaching and learning. They had no other program responsibilities at this time.

Data Collection and Analysis

Data sources include: video excerpts of group meetings with pre-service teachers; transcripts of individual interviews with pre-service teachers as they began their case projects and again as they completed them, and pre-service teachers' completed cases produced as webpages. Case projects were analyzed for the kinds of questions investigated and how pre-service teachers carried out those investigations. Their reflections on the process of creating their case were drawn from data collected during the practicum, through the interviews, and from their case projects. These data were analyzed using Wenger's (1998) concept of identity in terms of pre-service teachers' developing ideas about mathematics, how they saw themselves teaching mathematics, the role of inquiry in their teaching, and how each of these developed as they constructed

their cases. Data were analyzed using direct interpretation of student responses across the development of their case projects (Stake, 1995).

RESULTS AND DISCUSSION

Framing and Investigating a Question

Pre-service teachers in this study chose to focus their cases around a question or issue stemming from their experiences teaching mathematics in the practicum. Their questions focused on issues of mathematical communication and dispositions, promoting conceptual understanding or numeracy, and designing meaningful curriculum integration with mathematics. Jan, curious as to why her Grade 1 and 2 students were more creative problem solvers in science than mathematics posed the question: How can I develop students' mathematical dispositions? While Nat, noticing that her students rarely spoke during mathematics class asked: How can I improve my students' mathematical communication so that enhanced student learning can occur? These case questions are not questions which framed action research cycles or teacher research projects but are instead broad questions posed by pre-service teachers that stimulated their thinking about how they were and how they might help their students' learn mathematics.

In responding to these questions some pre-service teachers used video clips of their teaching and student thinking as a way of interpreting their question. Tes, for example, skeptical for how mathematics might be meaningfully learned through other disciplines, created a short video clip of her teaching an "integrated math lesson" and shared this with her peers, teachers, and teacher educators asking for their response to the questions "Is this curriculum integration? and What significant math do you think students' are learning?" Collecting this kind of information, together with an examination of the research literature on conceptual understanding, Tes was able to re-conceptualize what curriculum integration could be and how it might look in the mathematics classroom. Pre-service teachers' case reports were a collection of video clips and text built as a webpage with interactive links and opportunities for more public shared discussion. Some pre-service teachers used video clips to support their text while others used text to support their analysis of video clips.

Imagining new Possibilities as Learners and Teachers of Math

Analysis of pre-service teachers' comments collected during group meetings, their reflections contained in the case reports, and interviews conducted as they began their extensive response to their cases indicate that all pre-service teachers were somewhat apprehensive about pursuing a project that focused on mathematics education. All five pre-service teachers stated that they earned good marks in high school mathematics and two stated they were in advanced math groups in elementary and high school. Yet, all said they did not enjoy learning or doing mathematics. Most spoke about their lack of passion in learning mathematics compared to learning in other subject areas. Nel's comments are representative of others when she states "My experience in other areas, such as English, was more open-ended [than math], there was room for your opinions and what counted was how you justified them. In math it was either right or wrong, black or white. It was so contrived." When asked why they focused their projects on questions of mathematics teaching most stated that they saw it as an opportunity to improve their

teaching of math. No pre-service teacher spoke about it as an opportunity to improve her own understanding of math.

Comments made by participants toward the end of their projects and in the final interviews suggest that as they researched their questions they extended their views of themselves as mathematics learners. Most commented that they now recognize not only the importance of their attitude toward math but also the importance of their own understanding of math for teaching. Through an analysis of student interviews and their teaching, pre-service teachers came to see the need to enrich their own knowledge of math. Nel, for example, reports that from watching her interviews with students she "realized [that] if I want to ask students open-ended questions then I need to have a broad range of knowledge and solid math background. Not just knowing how to do things but being able to find the math so that I can ask creative questions." While Tes states: "I need to have a deeper understanding of math itself so that I can understand what students are saying and doing." These comments indicate that in the development of their case projects, pre-service teachers found opportunities to extend their understanding of math. Although, only two of the five participants pursued these opportunities in an in-depth way, all spoke about wanting to continue learning more about the math they were expected to teach. What is significant is that pre-service teachers did this in a way that they found exciting and engaging. Their desire to deepen their understanding of math came not with anxiety but with curiosity and commitment to make sense of their students' thinking and provide meaningful tasks that promote student understanding.

As their projects progressed participants also began to consider new possibilities for themselves as mathematics teachers. Many spoke about the importance of conceptual understanding and their interest in helping students communicate their thinking. Tan, for example, interested in helping students "use math to help them understand their world better" explored how she might help students learn math through a study of social issues such a poverty. Tes, as with others, began to see possibilities for teaching mathematics that they had not seen while in the practicum. Many described the project as "life altering" for offering news ways of thinking about their teaching and envisioning themselves as teachers. They explored mathematical connections, issues, and problems they had not considered while they were teaching. In summarizing her experiences with the project Nel wrote: "The project was so amazing because I don't see myself as the same teacher anymore."

Becoming Inquiring Teachers of Mathematics

An analysis of pre-service teachers' discourse during the development of their projects and in the final interviews highlights their increased awareness of the need to make sense of teaching. Many mentioned that during the practicum they were unable to think deeply about their teaching. They referred to the usefulness of the group meetings where they shared video clips of their teaching. Yet, when they were teaching they considered these meetings and discussions as "add-ons" to their practice rather than part of their practice. Others spoke about the value of sharing and analyzing video clips within a community and the possibilities these offered in "seeing things differently" or in "making it okay to take a risk to learn something new." Pre-service teachers' commitment to their

investigation of teaching is evident in their repeated comments that the project "totally occupied" or "consumed" their thoughts. Further evidence is seen in their desire to continue their investigations and pursue questions (e.g. the relationship between mathematical disposition and gender or the nature of mathematics curriculum that fosters narrow thinking) that they did not have a chance to address in their case projects.

Conclusion

The results of this study provide insight into the development of pre-service teachers' learning about mathematics, pedagogy, and inquiry. Studies of experienced and prospective teachers' subject-matter knowledge indicate that teachers require a rich and connected understanding of the mathematics they will be teaching in order to teach well. Ma's (1999) research suggests that teachers can develop their understanding of mathematics for teaching over their teaching careers as well as develop productive attitudes, such as an inclination to pursue conceptual understanding of a concept, seek alternative solutions to problems, and require mathematical reasoning to justify. All students in our study spoke about their interest in developing their own understanding of mathematics and the need for this in order to better understand and hear their students' thinking as well as create meaningful problems for their students to explore.

The results of our study indicate that with an investigation of their own teaching pre-service teachers came to develop a different relationship to the discipline of mathematics. Rather than seeing mathematics as uninteresting and disconnected it became a place of curiosity and intrigue as they sought to make sense of their students' mathematical work. Their identities of themselves as learners of mathematics were being shaped to include the desire to make sense of mathematics, pursue multiple solutions to problems, and make connections within and beyond the discipline. This was intricately tied to their images of themselves as mathematics teachers. Pre-service teachers recognized that with a deeper understanding of mathematics they were able to see possibilities for teaching mathematics that had previously gone unnoticed. Although pre-service teachers discussed how their case projects profoundly changed their views of mathematics, teaching mathematics, and what is involved in making sense of teaching, how they use these new understandings and attitudes in their practice as beginning teachers is an area for further research. That is, how these identities as learners and teachers of mathematics continue to be negotiated as these teachers participate in the culture of schools is an important question.

Pre-service teachers in this study chose mathematics as an area to investigate. They were likely ready to, as Jan, said "take the risk" and study an area that was not their strength or first interest. This raises questions on how we might provide opportunities to engage other students who may not be as ready or willing to take this risk. Participants in this study were also unique in that the tools offered as resources for their learning. They had opportunities to form a community of practice that valued the investigation of teaching. They sought each other's ideas and suggestions in their attempts to make sense of their teaching. They engaged in discussion, debate, and pursued different points of view as they shared clips of their teaching with each other. Participating in this community provided opportunities for negotiating identities, of providing new visions of who they

are as learners of mathematics, how they imagine themselves as teachers in relation to others, and how they see themselves as students of teaching.

Certainly access to new technologies as resources for their learning was a factor shaping this community of inquiry. Collecting digital video clips, editing these, and making short movies to share with others structured the kinds of discourse and inquiry questions pursued by participants. Three of the five pre-service teachers spoke about how different their work on this project was from their previous teacher education experiences. They did not consider their previous teacher education work as an opportunity for in-depth critical reflection. Nor was the practicum a place for such learning. Instead, pre-service teachers found they were best able to learn in and from practice with opportunities to collect evidence or artifacts of their teaching and with time afforded them after the practicum to discuss and research issues related to these.

This study shows that pre-service teacher education can have a profound influence on students' understanding of mathematics and pedagogy as well as their inclinations to learn mathematics and study mathematics teaching. This study provides insight into the possibilities of providing pre-service teachers with support and time to participate in a community of inquiry, to negotiate identities as inquiring teachers, and to include inquiry in their lives as teachers. Building on Boaler's (2002) work and Ma's (1999) research, this study emphasizes the interconnectedness of knowledge, practice, and identity, and points to the possibilities teacher education can offer in helping pre-service teachers develop a relationship to the discipline of mathematics and of teaching mathematics that involves learning in and from practice.

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