This paper draws on results from two qualitative studies. In the first study, eight instructors from seven institutions in south-western Canada were interviewed about their perceptions and approaches in teaching Math for Teachers (MFT) courses for elementary prospective teachers (Oesterle & Liljedahl, 2009). The second study involved interviews of 12 students from a university in the south-eastern United States who had completed MFT courses required in their elementary education program (Hart & Swars, 2009). The initial analysis and reporting of results from the two studies occurred independently. However, in a secondary analysis, two themes emerged that resonate across both studies: the importance of connections to the elementary classroom and the role of affect in student learning. This report will elaborate on these themes and discuss possible implications for teacher learning.
In response to ongoing concerns about the adequacy of the mathematical preparation of elementary teachers (Ma, 1990; Ball, Hill, & Bass, 2005; Rowland, Huckstep, & Thwaites, 2005), many institutions have developed and require prospective teachers to take specialised mathematics content courses. These courses, referred to here as Math for Teachers (MFT) courses, aim to provide a thorough understanding of elementary mathematics concepts in order to develop prospective teachers’ confidence and flexibility in teaching mathematics (Kilpatrick, Swafford, & Findell, 2001; Williams, 2008). These courses are most frequently taught in mathematics departments by mathematics faculty. Recent recommendations by the National Mathematics Advisory Panel (Greenberg & Walsh, 2008) endorse such courses, arguing for increasing the number of courses typically required and re-iterating that these courses should be taught by mathematicians.

This paper presents a synthesis of two separate research projects. The first study focuses on instructors of a MFT course at a number of institutions in south-western Canada. Although the MFT course had similar prescribed course content, the autonomy given to the instructors allowed for considerable variation in the course-as-delivered. This study sought to shed light on the instructors of the MFT course, as well as how their beliefs impact pedagogical decisions. The second study explored the voices of a group of students (i.e., prospective teachers) who had completed MFT courses at a university in the south-eastern United States. Joint consideration of the data from these research projects enriches understandings of the realities of MFT classrooms, revealing both the potentials and the constraints.

Recognition that teachers need more than content knowledge has resulted in efforts to identify specialised mathematics-for-teaching knowledge (Ball, Lubienski, & Mewborn, 2001; Ball, Thames, & Phelps, 2008). A desire to investigate the extent to which MFT course instructors address development of mathematics-for-teaching knowledge provided the initial motivation for the instructor-focused study. The student-focused study was inspired by concerns over the poor success rates for students enrolled in MFT courses and the limited extant literature on the experiences of elementary prospective teachers in such courses.

Related Research

Research relevant to this report includes: effective approaches to building mathematics knowledge for teachers, the role of affect, and characteristics of effective university mathematics instructors.

Studies on effective approaches tend to be in the context of pedagogy courses rather than content courses. An exception to this is Philipp’s et al. (2007) study, which examined the effects of field experiences on the mathematical content knowledge and beliefs of elementary prospective teachers, finding that those who participated in field experiences developed sophisticated pedagogical beliefs and improved mathematical content knowledge more so than those who did not. Another example is Royster, Harris, and Schoeps’ (1999) study, which explored the effects of modifying the delivery of a general mathematics course to reflect current reform
approaches. From their survey of 182 college students from various majors administered before and after a semester-long reform-based mathematics course, they found that elementary education majors showed the most positive change in dispositions toward mathematics in comparison to other majors, suggesting a positive link with a reform model of instruction in mathematics and this group of students.

The literature also recognizes the importance of affect in the preparation of teachers. These “emotions, attitudes, and beliefs” (Philipp, 2007, p. 259) influence teacher thinking and behavior, including instructional decision making (Philipp, 2007; Wilson & Cooney, 2002). Further, the beliefs of prospective teachers influence how and what they learn and have been identified as targets of change (Richardson, 1996). Beliefs of particular concern include mathematics self-efficacy and mathematics teaching efficacy, which are beliefs about capabilities to perform mathematics tasks and to effectively teach mathematics, respectively (Bandura, 1986; Pajares, 1996). Higher mathematics self-efficacy has been correlated with higher performance on standardized tests (Pajares & Graham, 1999), while higher mathematics teaching efficacy has been linked with a willingness to adopt reform strategies in the classroom (Riggs & Enochs, 1990) and to improved student achievement (Anderson, Green, & Loewen, 1988). Further, studies confirm that relatively high mathematics anxiety is common amongst prospective elementary teachers (e.g., Hembree, 1990).

There is a general lack of research on post-secondary instructors of mathematics courses; however, there is a group of studies which considers students’ perceptions of effective mathematics teaching at this level. According to these studies, students identified a number of characteristics of exemplary teaching practices in mathematics courses, including adequate instructor availability, prevalence of classroom discourse, clear instructor explanations, and a classroom with a caring ethic (Powell-Mikle, 2003), as well as decreased lecture and a focus on helping students to develop confidence (Weinstein, 2004). In contrast, three factors contribute to a negative learning atmosphere in mathematics classes: difficulty of course content, professor’s teaching style/personality, and personality styles of classmates (Schulze & Tomal, 2006).

**Methods**

Data were collected by interviewing two groups of participants: instructors of elementary MFT courses and students (i.e., prospective teachers) in elementary MFT courses.

**Instructor Interviews**

Instructor data were gathered through semi-formal interviews conducted with eight instructors of MFT courses at seven post-secondary institutions in British Columbia. Theoretical sampling was used to select instructors who represented a range of years of experience teaching the MFT course and who came from a wide variety of post-secondary institutions. At the institutions
only one MFT course is required, and it is offered through the mathematics department. Courses are locally developed but offer similar content.

The instructor interviews were approximately one hour in length and began with questions about the background of the instructor, including education, number of years teaching, and number of years teaching the MFT course. Then questions were asked about initial orientation (preparation) for teaching the course, about what is done differently with this group of students compared to other mathematics students, about goals in teaching the course, and about the outcomes achieved. Since the interviewer was also a MFT instructor, member checking was employed to mitigate bias due to prior experiences.

As each interview was completed it was transcribed and coded for emergent themes through a process of constant comparative analysis. Given this reflexive process, the interviews were semi-structured, which allowed the interviewer to incorporate additional and/or deeper questions to respond to new themes as they arose.

Student Interviews

Twelve students (11 females and 1 male) were interviewed from one urban university in the south-eastern US. They had completed three or four MFT courses. They were randomly selected from 4 cohorts of students in the elementary teacher preparation program with a combined size of 99 students, thus representing approximately 12% of the total population. Collectively they had taken 42 sections of MFT courses. At the time of this study, all of the students were in the last semester of the program and participating in student teaching.

Student interviews were around 45 minutes and involved a general interview guide. Questions were related to overall impressions of the courses, if it was easy or hard, and what they liked or disliked. They were also asked if they felt their content knowledge was sufficient to understand PreK-5 mathematics and if they felt prepared to analyze children’s mathematical strategies. These interviews were semi-structured, so questions were only a starting point for the discussion with interesting comments or remarks probed in-depth.

Audiotapes of the interviews were transcribed and analysis of the data began by considering segments focusing on a certain topic or question. The segments were then analyzed using line-by-line open coding which generated meaning units documented in a coding manual. These meaning units were compared across cases as we engaged in data reduction while using the coding manual for guidance in comparing and refining these units. As consensus was reached between the researchers, coded meaning units were collapsed and renamed until final themes were identified.

Results

In the instructor-focused study, eight themes emerged: instructor identity, tensions, and resources, student knowledge and affect, orientation to
mathematics, orientation to teaching, and classroom environment. In the student-focused study, three themes emerged including domains of mismatch (with three sub-areas), affective reactions, and classroom practices. Although the studies were in differing settings, two themes appear to resonate among the instructors and students: connections to the elementary classroom and affect of the students.

The Instructors

The instructor-focused study revealed a wide variety of approaches to the course taken by MFT instructors. For this report, the results will be limited to data from interviews with only two of the instructors, Harriet and Bob, in relation to the themes connections to the elementary classroom and student affect. Elaboration on these cases will permit illustrations of two divergent perspectives on teaching the MFT course and will provide a sufficient basis for discussion.

Harriet and Bob are both experienced instructors, having taught in mathematics departments for 22 and 13 years, respectively. Harriet is relatively new to teaching the MFT course but taught the course six times over three years, while Bob taught it nine times over nine years. Both have Master’s degrees in mathematics but neither took mathematics education courses nor had formal teacher training. Harriet was initiated into teaching the MFT course by a colleague with a Master’s degree in mathematics education who taught MFT courses for many years. This colleague provided information about course materials and activities, as well as the nature of the students and their difficulties. Bob’s first forays into teaching the course were guided by his institution’s curriculum, the textbook, and informal discussions with colleagues.

Connections to the Elementary Classroom. Harriet’s descriptions of her goals and strategies for teaching the MFT course are permeated with comments related to mathematics-for-teaching knowledge (Ball & Bass, 2003) and how her students’ learning relates to their future as teachers. When asked if there is anything that she teaches MFT students about fractions that she would not teach other students, she states: ‘The fact that there are different models, there are different ways of picturing what’s going on, and that they are appropriate for [...] what may work well for some situation, or for some [elementary school] student, may not work for some other one.’

She also emphasizes connections between mathematical ideas both within and across grade levels. She explains:

At all times I connect it [the course content], as far as I can, to what goes on at different levels. What you might do with a grade 1 class, how that connects to what they’re going to see in, you know grade 4 or 5 or something like that, how that connects to what they might do in high school and how that connects to what I’m doing in Calculus. Because they’ve got to see how it’s connected, and how we build bigger and bigger [...] understandings of sets of numbers, or calculations.
Harriet does not just pay lip-service to these ideas. She describes assignments that allow her students to build their mathematics-for-teaching knowledge, such as analysis of pupil errors and discussion of alternative solutions.

In contrast, Bob makes very little reference to mathematics-for-teaching knowledge. His emphasis is instead on developing a strong understanding of fundamental mathematics and communication skills. Varieties of algorithms and models form part of his course content, but he does not specifically address how they can be applied differently at various grade levels.

Bob needed to be pressed by the interviewer to consider what aspects of the course content might be particularly relevant to prospective teachers as opposed to general learners of mathematics. Initially his comments revolve around his teaching methods, such as the use of group work and manipulatives, but he makes no reference to any special mathematics knowledge for teaching. Eventually he describes challenging his students to think about the kinds of questions that they will encounter as teachers:

. . . what kinds of questions will you encounter? And why is it important that you to be able to communicate your ideas effectively, [...] why should you understand this material to the most, [...], fundamental and basic level, and understand all of the structure?

He adds:

when you get some of these obtuse questions, that are seemingly [...] obtuse, you have to be able to appreciate it and be able to differentiate whether that’s something that can lead you into a teachable moment

His response appears to be a justification for his goals of developing strong mathematics content knowledge and communication skills. For Bob, mastery of the subject content along with general pedagogical skills seems to be sufficient for the teaching of mathematics—a traditional and prevalent point of view (Hill et al., 2007).

Student Affect. Both Bob and Harriet describe their students as suffering from mathematics anxiety and lack of confidence in their ability to do mathematics. However, there are considerable differences in their approaches to these negative affective states.

Harriet observes that her students: ‘are very anxious around problem solving. They are just terrified, most of them, of a problem they haven’t seen before.’ Her efforts to address this seem to be centred on changing their ideas of what the enterprise of mathematics is all about. She tries to convince them that ‘we’re supposed to have fun with this’ and tells her students that ‘you may never have seen it; you might not get all the way through it. But what I’m looking for is how far did you get, and how well can you explain what it is that you got’, shifting the focus away from getting the right answer toward less threatening goals.

By the end of the course she hopes her students have grown in confidence and also ‘they have more of a sense of play [...] I think they’re more flexible. They think they’re more flexible. They’re not as scared if [...] that someone will ask them a question that they can’t answer.’

Bob describes his students as believing that mathematics is arbitrary and incomprehensible: ‘So many things seem magical to them’. He affirms that ‘it’s not your standard sort of math group, it’s one that has encountered some
challenges along the way, and it hasn’t always left them with a positive impression of mathematics.’ In his view, their confusion and anxiety is closely linked to their skills:

In many cases, some of the very elementary arithmetic operations are in fact, confused in their minds and so when they hit upon things, in particular when you hit rational numbers, as an example, that’s one place where students have a great deal of anxiety and they would demonstrate poor understanding of ideas.

More than once he describes the MFT course as a second start for these students. He attempts to reshape their beliefs and attitudes by providing them with opportunities to see the logical structure of mathematics and deepen their understanding. For Bob, the course ‘focuses on a very sound fundamental ability to appreciate it [mathematics], in a theoretical way, why things work, as opposed to technical aspects of how do you do mathematics.’ However, although he believes that improved skills will lead to increased appreciation and confidence, he confesses that the realities of the course conspire against this occurring. Early in the interview he expresses a wish that his MFT students develop a love of math, but when asked about whether this goal is accomplished, he admits: ‘in terms of the other goal, for love of math? Unfortunately, the course is so packed, that in some ways, I think they do get a little bit beaten by the end, and they’re just tired.’ This statement illustrates Bob’s realisation that the volume of content covered in a limited time is at odds with his affective goals.

The Students

Connections to the Elementary Classroom. After experiencing other courses in their teacher preparation program, the students were acutely aware of disconnections between their experiences in the mathematics content courses and other experiences in the program. The students frequently described an inability to position the mathematics content coursework within their growth as educators, which led to perceptions of lack of usefulness or relevance of the courses as evidenced by this statement: ‘I mean a lot of us were always questioning, you know, why we have to take these math courses...It’s not even necessary.’ Similarly, another student stated, ‘The reason why we were taking those courses was never brought to our attention. We had no clue why we were taking those classes, no clue...It seemed very unnecessary.’ Another student said:

It [mathematics courses] had no connection to elementary schools. Anybody could take those courses. I don’t think we ever talked about kids. I seriously don’t think we ever talked about teaching or students or anything like that. I just don’t remember ever that connection.

Another student explained the lack of connection with elementary classrooms as, ‘In our [elementary] classrooms right now, you know, they’re not graphing how many bagels and coffee people are going to eat and drink tomorrow. It was just not very logical for, you know, a kindergartner.’ The following statements further support this sentiment: They’re [mathematics instructors] blind to what we are actually doing with our lives’; ‘[Elementary]
Students were never even brought up... I mean, students or when you get your own classroom were never brought up’; and ‘We’re thinking we’re learning something about how to be teachers. But, in reality we’re learning how to get through their math courses.’ Ideas for changing the courses include: ‘Get some teachers who were actually qualified in elementary [teaching]... They actually know what children are going through and that would help;’ ‘They [mathematics instructors] could talk to elementary teachers;’ and ‘Maybe have us students say, hey, this is what is going on in my [elementary] classroom.’

Student Affect. A second theme across the interviews was students’ affective reactions to the coursework experiences. Many statements described negative emotions, for example, they used words such as ‘emotional wreck’, ‘so stressed’, ‘very belittling’, ‘discouraged’, ‘terrified’, ‘struggling’, and ‘frustrating’. A student asserted, ‘I felt like I was just hanging on. Just trying to dig myself out of a hole, and I kept falling down.’ The students portrayed the courses as having deleterious influences on their mathematics teaching efficacy beliefs and self-efficacy beliefs, which were often linked with the classroom practices of the instructors. Most often, descriptions of ineffective pedagogy were related to traditional approaches to instruction. The students mentioned a preponderance of ‘lecture,’ ‘note-taking,’ and ‘power point presentations,’ and asserted the ‘classes were not hands-on.’ In describing how the courses impacted teaching efficacy beliefs, a student stated, ‘I felt less confident [about teaching mathematics] when I walked out of those classes because it’s just so much and it just seemed so unnecessary... It was just very discouraging.’ In response to a question on how the courses prepared her to teach elementary mathematics, a student stated the courses made her, ‘Feel less prepared. Feeling more scared, definitely.’ One student attributed this negative impact on her teaching efficacy to the attitude of the instructor of the course, ‘The attitude was if you don’t get this [math content], you won’t be able to teach it, basically.’

The experiences in the courses also influenced self-efficacy beliefs in mathematics as represented by this student’s statement:

[I felt] terrified, struggling, especially in geometry. It was just, it was very frustrating because I didn’t get it. I didn’t understand why we’re doing what we were doing, how we were coming out with the answer, and especially if I didn’t get the answer right.

Further, another student stated:

Like geometry... I came out of there in tears. I felt very disappointed. I felt stupid. I felt alone. And, I know that I am an intelligent person, or I have the potential to learn something. If I don’t know it, I’m willing to give up my time and my efforts. But, I felt like my efforts didn’t matter.

Similarly, another student said, “It (mathematics courses) made me feel so low in math. Even though I knew those math courses, I would never be teaching that stuff... It totally lowered my self-esteem in mathematics.”
Discussion

Although the two groups of participants in these studies were in different settings, the data when juxtaposed reveals salient commonalities. The findings provide important insights into issues and concerns around creating experiences in MFT courses that best support elementary prospective teachers’ learning of mathematics.

The student voices emphatically call for the need for a connection between the mathematics content and the elementary classroom. Without this connection, the students were not able to find relevance in their learning. This need is recognised in the literature [see Philip (2007) above]. Ball and Bass (2003) also strongly advocate for this link:

*Practice in solving the mathematical problems they will face in their work would help teachers learn to use mathematics in the ways they will face in their work would help teachers learn to use mathematics in the ways they will do so in practice, and is likely also to strengthen and deepen their understanding of the ideas.* (p. 13).

The instructor-focused study reveals how differently instructors may perceive the need for incorporating these connections. Harriet is very aware that these links help to motivate her students, helping them to see why a deeper understanding of mathematics is required of them in this course as compared to their previous mathematics courses. For Bob, making these connections is not an explicit part of his course. One reason for this may be that, as a mathematician, his lack of experience in elementary classrooms limits his ability to do so. However, Harriet also lacks such experience. Another possibility is that Bob takes such connections for granted. His inability to identify content in his course that would be particularly relevant to future teachers of mathematics as opposed to general mathematics students reflects a lack of awareness of specialised mathematics knowledge-for-teaching knowledge. For Bob, subject content knowledge and pedagogical knowledge are distinct. He sees his role as supporting the development of the former.

With regard to the theme of affect, the student-focused study reports an alarming number of negative comments, indicating increases in students’ anxiety and decreases in self-efficacy. Both instructors are acutely aware of the impact of affect and describe their students as coming into the course with high mathematics anxiety and lack of confidence. However, their perceptions about the cause of the anxiety and strategies for addressing it were quite different. For Bob, the source is students’ lack of fundamental skills. As a result, his solution is to help them see the logical structures of mathematics and develop these skills, though he acknowledges that the sheer volume of the material he must cover, in fact, adds to his students’ stress. For Harriet the source is negative past experiences and a perception of mathematics as rigid. Her efforts focus on moving students away from the ‘one right answer’ view of mathematics, helping them develop more flexibility in approaching mathematical problems and to just have *fun*. 
From the students we hear that traditional instructional methods of lecture, power point presentations, and drill and practice tended to elevate anxiety and decrease efficacy, while reform approaches such as small group work, hands-on learning, and opportunities to share and discuss were less stressful and increased efficacy. They also shared that a caring manner, an approachable demeanour, and a perceived willingness to help supported their learning. This echoes the research cited above. Regardless of their perceptions of the source of their students’ anxieties, knowledge of this research could help inform instructor choices with respect to how to address concerns around student affect.

The voices of the students in the student-focused study lend support to concerns that mathematicians in mathematics departments may be unprepared to take on the task of preparing elementary teachers. The lack of connections of content with the elementary classroom and the traditional teaching approaches seem to have contributed to frustration, increased anxiety, and decreased self-efficacy. However, the instructor-focused study shows that though lack of explicit connections to elementary learning may occur, this need not be so. The differences between Harriet and Bob in this regard may have been the result of the mentorship Harriet received, suggesting a potential means for supporting the mathematicians who teach these courses.

The other side of this debate is that mathematicians, at their best, have much to offer future teachers, even at the elementary school level (Hodgson, 2001; Williams, 2008). Jonker (in review) describes mathematicians in mathematics departments as ‘stewards of their discipline,’ ‘passionate about mathematics’, and ‘eager to share their excitement with students and concerned about the place of mathematics in the world.’ The challenge is to create opportunities for conversations between mathematics educators and mathematicians so that students in MFT courses are better prepared to teach mathematics to children.

References


Richardson, V. (1996). The role of attitudes and beliefs in learning to teach. In J. Sikula, T. J. Buttery, & E. Guyton (Eds.), Handbook of research on


