

THE INFLUENCE OF PRE-SERVICE MATHEMATICS METHODS INSTRUCTION ON MATH ANXIETY AND IMPLEMENTATION OF REFORM-BASED APPROACHES AND STRATEGIES

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Abstract

This paper reports the results of a study conducted by the instructor of a pre-service mathematics methods course for the purpose of improving her teaching practice and course design. Novice teachers who graduated from the course were questioned about their math anxiety levels and use of approaches and strategies in their own math programs. They were encouraged to comment on the course and suggest improvements. The study provides an interesting picture of novice math teaching and suggests possible changes to the course. The discussion and analysis are framed within the context of current literature on pre-service mathematics education. Questions arising from the data are proposed for future study.

Introduction

According to the Ontario mathematics curriculum document (2005), the teacher's role includes developing appropriate instructional and assessment strategies, differentiating curriculum to meet diverse student needs, relating mathematics to real world contexts, providing students with numerous opportunities to solve problems and reason mathematically, bringing enthusiasm, and creating classroom environments that engage students in understanding mathematics critical to future learning (p.5). This is a tall order for any teacher, but may be particularly challenging for beginning math teachers, who struggle with unfamiliar content, educational philosophies, and instructional approaches (Ball, 1988; Hill, 1997).

The National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* (2000) provides a vision for mathematics teaching that underpins the Ontario curriculum. It outlines reform approaches to teaching mathematics, including problem-solving, reasoning and proving, reflecting, selecting tools and computational strategies, making connections, representing, and communicating are central to this document as well as to the Ontario curriculum. Research on pre-service math preparation supports the use of reform-based approaches to help pre-service teachers deepen their understanding of mathematics (Cuoco, 2001; Lowery, 2002; Ward, 2005).

Ellis and Berry III (2005) encourage mathematics educators to reflect on their own instructional practices and critically examine the sorts of learning opportunities that they create for their students. In this paper, I will describe an action research study I conducted as a pre-service math educator for elementary teacher candidates. In the interest of improving my teaching practice and course design, I approached graduates from my math methods course to ask about their perceptions of my math methods course and to find out what strategies they were using in their own classes.

My course comprises twelve three-hour classes within an eight-month, post-degree program. The course content is based on the Ontario mathematics curriculum, a textbook (van de Walle & Folk, 2005), and supplementary readings. Reform-based teaching and assessment techniques are modeled throughout the course with many opportunities for candidates to practice them in cooperative groups. Assignments provide teacher candidates with practical experience in teaching and assessment strategies and are linked to their practicum experiences when possible.

Schoenfield (2002) reminds us that teaching for mathematical understanding is difficult. It requires deep understanding of the mathematics involved and of ways to create instructional contexts that lead students to engage with mathematics in meaningful ways. Elementary teachers tend to struggle with the mathematics they teach (Aitken, 2007; Ball, Hill & Bass, 2005; Craven, 2003; Hill, 1997; Ma, 1999). Even those with more extensive background may have difficulty relating what they know about mathematics to what they are expected to teach their students (Ball, 2000; Cuoco, 2001; Wu, 2002), and difficulties are exasperated by the high levels of math anxiety and dislike for the subject (Boaler, 1998; Cornell, 1999; Hembree, 1990).

An important step in learning to use reform approaches involves thinking differently about mathematics and strengthening conceptual understandings, moving beyond rote facts, skills, and procedures to include important mathematical ideas their interconnections (Ma, 1999). For many teacher candidates, taking this step will mean re-evaluating the mathematics teaching methods they remember their own elementary teachers using. As Brookfield (1995) tells us, "the most significant and most deeply embedded influences that operate on us are the images, models, and conceptions of teaching derived from our own experiences as learners" (p. 49-50). Pre-service courses have an important role to play in helping new teachers prepare to teach math well.

Methodology

The purpose of this study was to help me improve my own practice as a pre-service mathematics methods instructor. In particular, I was interested in the first-year mathematics teaching experiences of graduates from my math methods course to learn how well the content, philosophy, and practical activities in the course met their needs. What were their perceptions of the course? Did the course succeed in helping them to overcome their own insecurities about teaching mathematics? What did they find useful? What strategies and approaches did they choose to implement in their own classrooms? What were their challenges as they began their own math programs?

I designed a questionnaire modeled on an earlier one that I had used in a previous study (Tait, 2005) and on guidelines suggested by Punch (2001, pp. 95 – 96), although, for logistical reasons, it was not pre-tested. The first section consisted of three questions about the participants' perceived levels of math anxiety at the beginning and end of the course and once they started to teach math. The second section included 15 questions about the teachers' new job situations (ex. *When were you hired to teach math? Did your classroom have math materials in it? Are other people teaching math at the same grade level as you are?*) The third section consisted of 30 statements about math teaching strategies and approaches, and the participants' sense of efficacy as teachers of mathematics. Participants were asked to use a 5-point scale (*1-never, 2-seldom, 3-occasionally, 4-usually, 5-always*) to indicate their frequency of use of different strategies (ex. *I give speed drills. I ask students to explain their thinking. I connect math to real life. I integrate math with other subjects.*) and their own perceptions of their effectiveness as teachers of mathematics (ex. *I am confident that I can teach math. I am able to teach math to all of my students.*). The next section included five open-ended questions about suggestions for changes in the math methods course based on their experience as first year teachers and the participants' professional development in mathematics teaching since graduation. Finally, participants were asked to make any additional comments about their preparation to teach math, their own math programs, or other related issues.

To recruit participants, I opted to use what Punch (2001) calls "purposive sampling" (p. 193) since I was looking for teachers with particular characteristics. In order to answer my questions, I needed to locate graduates from my math methods course who had been hired to teach full-time in the following school year and were teaching math as part of their assignment. In the spring of 2006, after receiving ethical approval from the University of Ottawa, I sent an email to the all graduates of my York University 2004-05 math methods course describing the study and explaining the required participant characteristics.

Twelve teachers responded to the email and indicated an interest in participating. This was a good response, since, based on informal tracking of our graduates, many of the other members of the class were either not teaching full-time or were teaching subjects other than math. Of the twelve volunteers, two were excluded from the sample, one because he was not teaching math on a regular basis, and one because she was supply teaching. There were three men and seven women in the final sample. All of them had a university degree before they began their teacher training, although seven of them had not taken any math courses since high school. All had been hired to teach in Toronto area elementary schools and all were teaching math as part of their assignment.

I sent each of these teachers a package including an informed consent form, the questionnaire, and a self-addressed, stamped return envelope. Everything was returned to me by May 2006. Using the Miles and Huberman (1994) framework for qualitative analysis as a guide, I sorted, grouped, and tabulated questionnaire responses according to themes and cross-referenced them with comments to the open-ended questions. The responses in different categories was recorded and charted in various ways to help move the analysis forward. The responses to the open-ended questions were read many times and notations were made in the margins as recurring themes and issues emerged. Three questions to help me focus my analysis:

- How did the participants' perceived math anxiety levels change over time?
- What approaches and strategies highlighted in the math methods course became part of the practice of first-year teachers of mathematics?
- What were the participants' perceptions of the math methods course and its content and how can they inform my future planning and course design?

Findings and Discussion

The questionnaire data provide interesting information about new teachers' math anxiety, their implementation of reform-based approaches, and direction for improvements in my math methods course.

1. How did the perceived math anxiety levels of the participants change over time?

Because there was no baseline data available against which to compare participants reported levels of math anxiety, participants were asked to rate their level of math anxiety at the beginning of the course, at the end of the course, and once they started teaching (see Table 1 below). While there are limitations inherent in the self-report data approach, Baldwin (2000) supports it, calling personal opinions, feelings, and memories "information no one else knows" (p. 3). In this case, I believe self-report data was a useful and appropriate approach to take.

Two teachers reported that they believed that their level of math anxiety had not changed at all from the beginning of the course to the time they responded to the questionnaire. Eight reported the their anxiety level had dropped by the end of the math methods course, in three cases from high to low, and in four cases from moderate to low. No one reported an increase in math anxiety over the duration of the course. At the end of the course, nine people rated their math anxiety level as low and one as moderate.

For five of the ten, perceived math anxiety increased from low to moderate levels once they confronted the realities of teaching mathematics. However, for all but one of the teachers, their level of math anxiety once they started teaching was lower than when they started the math methods course. One teacher who reported low levels of math anxiety throughout the course reported an increase in her math anxiety level once she had actually started to teach mathematics. No one reported a return to high levels of math anxiety.

Table 1: Changes in participants perceived level of math anxiety from the beginning of the course to the beginning of teaching

Participant #	Beginning of the course	End of the course	Beginning of teaching
1	high	low	moderate
2	low	low	low
3	low	low	moderate
4	moderate	low	moderate
5	moderate	low	low
6	moderate	moderate	moderate
7	high	low	low
8	moderate	low	moderate
9	high	low	moderate
10	moderate	low	low

In their comments, teachers wrote that the math course "made me less anxious and gave me confidence", "it lowered my level of math anxiety" and it "helped to diminish insecurities about teaching math". Woolfolk and Hoy (1990) reported that efficacy beliefs appear to increase during university course work, then decline when novice teachers are confronted with the realities and complexities of teaching. This study confirms this finding with respect to confidence in the ability to teach math, which increased from the beginning to the end of the course, but fell once the participants began teaching in their own classrooms.

Although all participants reported an overall decrease in math anxiety, it is not possible in this study to say whether it was the course content, the teaching approach, the underlying philosophy, classroom experiences, or a combination of these that students found helpful.

2. What approaches and strategies highlighted in the math methods course were carried over to become part of the practice of first-year teachers of mathematics?

There was a considerable variety of teaching strategies and approaches used by the ten respondents to the questionnaire. All ten reported that they usually or always followed the Ontario math curriculum and six said they usually or always used Ministry math support documents. Several reform strategies and approaches taught in the course were usually or always used by a majority of the participants, as shown in Table 2.

Table 2: Reform strategies and approaches used "usually" or "always" by five or more of the ten participants

Strategy or approach	Usually	Always	Total/10
I use performance-based assessments.	4	2	6
I ask students to explain their thinking.	2	5	7
I use a problem-solving format.	6	1	7
I connect math to real life.	4	4	8
I use cooperative groupings in math.	4	3	7

Other reform approaches and strategies that had received considerable emphasis in the course were not being used on a regular basis by a majority of the participants. These are summarized in Table 3.

Table 3: Reform strategies and approaches that less than five participants reported using "usually" or "always"

Strategy or approach	Usually	Always	Total/10
I use math manipulatives in my lessons.	2	1	3
I use children's literature in my math lessons.	1	2	3
My students keep a math journal.	3	1	4

Technology is part of my math program.	2	1	3
I integrate math with other subjects.	3	1	4
I differentiate instruction for special education and ESL students.	2	2	4
I use multi-cultural materials and approaches.	3		3

Some of the more traditional approaches that had been actively discouraged in the math methods course had nonetheless been adopted by some of the participants. Nine teachers reported using speed drills some of the time; eight said they used worksheets regularly; and seven grouped their students by math ability level.

Six of the ten used a math textbook as a teaching tool, and five used the teacher's guide to help them plan. As Betts and Frost (2000) suggest, teachers with limited mathematics background and experience often resort to textbooks as their primary teaching resource, and they are poorly equipped to evaluate or use them appropriately. Unfortunately, the wording of the question about textbook use was not specific enough to determine how or why the novice teachers were using the textbook rather than developing their own lessons and activities.

Drake (2002) found that novice math teachers reported the lowest level of reform teaching practices and a high level of traditional practices. Steele (2001) and Vacc and Bright (1999) also found that following a math methods course focusing on reform approaches to teaching mathematics, teachers adopted more traditional instructional practices once they had entered the classroom. In this study, one participant commented that as a first-year teacher, it was very difficult to implement many of the ideas that had been suggested in the course, adding "I just wanted to make it through the year successfully". Other teachers cited time constraints and a lack of materials and resources as frustrations that affected their ability to use certain strategies.

Drake (2002) also found that the use of reform approaches increases as teachers move in the mid-career stage, and Cady, Meier and Lubinsky (2006) suggest that once teachers become familiar with their school routine and environment, they are able to focus on improving their practice and once again reflect on the approaches recommended in their pre-service classes. With these intriguing findings in mind, it would be interesting to revisit the mathematics teaching practices of the teachers in this study in several years to see if there has been a shift towards the more frequent use of reform approaches and strategies.

3. What were the participants' perceptions of the math methods course and its content and how can they inform my planning and course design?

Overall, the participants were very positive about the math methods course and its content. Some of the comments included "extremely helpful", "best course I took", "a good foundation", "It really showed me the importance of having manipulatives for students and how math should be made an experience whenever possible", "I enjoyed it and learned a lot", "I developed new methods to help students succeed", "provided me with math resources", and "made me realize that math is fun to teach".

There were several specific suggestions for improvements to the course. Teaching unit and long-range planning was the most commonly suggested improvement, mentioned by five teachers. Other suggestions included finding a different text book for the course (one), offering additional suggestions for resources (two), providing more information about the textbook series commonly purchased by schools and how to use them (one), spending more time on how to set up a math program (two), lengthening the duration of the course (two), more focus on alternative assessment methods (one), and more information about and strategies to work with students with learning disabilities (one). Several participants expressed an interest in meeting with and observing expert math teachers. Having competent role models is an important way to build teacher efficacy (Bandura, 1997), and this suggestion

for improvement is an excellent one.

The number of participants who suggested adding course content on unit and long-range planning is an interesting feature of the data. This topic has not been covered at all in my course in the past, although unit planning is taught in another curriculum course and is the basis for a major assignment in that course. This leads me to wonder if new teachers are able to transfer the knowledge and skills required for unit and long-range planning from one curriculum area to another, or if these skills need to be explicitly addressed in different courses. Teaching unit and long-range planning in the math course would provide opportunities for me to model (and for students to practice) how to incorporate concrete materials, children's literature, and technology as part of a balanced math program, and how to integrate math with other curriculum areas. Perhaps concrete examples of planning and integration techniques would increase candidates' comfort levels and expertise with these teaching approaches and lead them to use the techniques to a greater degree in their own classrooms.

Final Thoughts

Research on the fit between the preparation of beginning math teachers in Ontario and their first-year teaching experiences is limited. Working with feedback from a previous graduating class has given me insight into my own practice and helped me frame my planning for future versions of my course. This study showed me that despite the content and emphasis in my math methods course, beginning teachers who had graduated from my math methods course were either not able or chose not to implement some of the reform-based approaches they had studied. I have a better understanding about what new teachers are able to do with their limited knowledge and experience and renewed respect for the way they confront the realities and complexity of teaching. There are certain topics in the course I will rework and some that I will add.

Late hiring is the current trend in the province, and in this study, only two teachers were hired before the beginning of the school year. More time and attention is needed to discuss the initial set-up of a math program since it is likely that few teachers will have much time to organize before they begin to teach. To respond to the nature of the teaching positions that new graduates are being offered, it would appear important to incorporate more information about teaching mathematics in increasingly diverse classrooms. Math instruction for students with learning disabilities and/or who are learning English as a second-language is very challenging for novice and experienced teachers alike. Topics such as universal design (Bowe, 2000) and/or culturally-responsive teaching (Ball, Gaffney & Bass, 2005; Ladson-Billings, 1995) could be useful additions to the course.

There are questions that arose from this study that I would like to explore in future. I would like to know more about why graduates do not use certain reform strategies and approaches to a greater degree in their own program planning and implementation. I would like to explore ways to support teacher candidates in working with heterogeneous groups and spend more time on ways to differentiate math instruction. In a future study, I would collect baseline data about participants' math anxiety levels and ask questions to identify which elements of the course were seen to be most effective in reducing math anxiety. I would ask more detailed questions about the reasons for and ways in which teachers are using math textbooks so that I could plan a more focused discussion of their role in the math classroom and give students guidelines and practice in how to evaluate them. Looking at novice teachers' ability to transfer planning skills from one subject area to another would be an interesting topic for a future study. Once course changes have been implemented, it would be interesting to repeat this study, with the previously mentioned modifications to the methodology and questionnaire and with a larger number of participants if possible, to determine the value of the participants' suggestions.

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