Performing or Learning Mathematics? Asking Critical Questions in Teacher Education

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Abstract
In the study reported here, preservice teachers were asked questions about their experiences of learning and teaching mathematics. Goal theory is used as a theoretical perspective for examining their responses to questions about what it means to know (in) mathematics and the role of the teacher in how students focus their efforts in mathematics classrooms. Also discussed in the paper is the role of the cooperating teacher in helping preservice teachers develop their ideas about what it means to be a “good” mathematics teacher. This is followed by a discussion of preservice teachers’ responses to questions concerning their perceptions of what it means to know (in) mathematics and their most meaningful experiences in the mathematics classroom during their internship. Finally, the paper highlights critical questions regarding the changing needs of teacher education programs in the context of preservice teachers’ internship experiences.

Introduction
What makes some students pursue challenges in learning mathematics while others withdraw when faced with difficulty? What does it mean to be a “good” mathematics teacher? What does it mean to know (in) mathematics? This paper explores some of the issues surrounding motivations, approaches, and attitudes and beliefs toward learning mathematics, particularly with regard to how these issues might influence beginning mathematics teachers. To assist teachers in reflecting on their own practice and critically examining curricula, we asked preservice teachers questions on their past experiences as

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students learning mathematics and about their internship experiences of teaching mathematics. We felt it was important to examine both their learning and teaching experiences since we had observed discrepancies between how some preservice teachers proposed to teach mathematics and how they actually taught during their internship. We are concerned that research in mathematics education does not adequately address the gap between theory and practice, between what preservice teachers say about what it means to know (in) mathematics and the approaches used in the teaching of mathematics. In other words, how can we help direct their efforts towards the issue of “walking the talk?”

In this study, we analyzed the responses of twenty-seven elementary and secondary preservice teachers who had recently completed their four-month school internship. These preservice teacher participants were recruited through their mathematics curriculum and instruction courses in the final semester of their undergraduate teacher education program at a Canadian university. As these participants are both ‘students’ and ‘preservice teachers,’ they are referred to as such throughout this paper.

The survey administered was divided into two parts: the first asked participants to use a Likert scale to indicate the degree to which they agreed or disagreed with various statements about the teaching and learning of mathematics. The second part of the survey consisted of open-ended questions, providing preservice teachers with more opportunity for elaboration. In the paper we ask critical questions of teacher education programs in the context of some of the responses to this survey. The first part of the paper explores goal theory as a perspective for examining the role of the teacher in the focusing of students’ efforts in mathematics classrooms and the issue of what it means to know (in) mathematics. The second section examines the role of the cooperating teacher as an influence in preservice teachers’ development of their ideas on what it means to be a “good” mathematics teacher. In the third section, preservice teachers’ responses to questions concerning their perceptions of what it means to know (in) mathematics and their most meaningful experiences in the mathematics classroom during their internship are discussed. Finally, the paper concludes by highlighting critical questions that have implications for teacher education.

Goal Theory and Motivation

Factors other than ability influence students’ approaches to challenges, their persistence (or withdrawal) when facing difficulties, and how they use cognitive skills (Dweck, 1986). Researchers have demonstrated that nonintellectual dispositions, including effective study behaviours and controlled exam anxiety, may improve the prediction of academic success beyond academic and intellectual dispositions (Larose, Robertson, Roy, & Legault, 1998). Achievement motivation is one such nonintellectual factor. Achievement motivation involves two classes of goals:

(a) learning goals, in which individuals seek to increase their competence, to understand or master something new, and (b) performance goals, in which individuals seek to gain favorable
judgments of their competence or avoid negative judgments of their competence (Dweck 1986, p. 1040).

Learning goals (also called task goals) (e.g., Anderman & Maehr, 1994) or mastery goals (Ames & Archer, 1988) seem to reflect intrinsic motivation while performance goals (or ability goals) (Anderman & Maehr, 1994) reflect extrinsic motivation. To expand upon the definitions of these goals, we turn to Anderman and Maehr (1994, p. 295). Students with learning goals define success as improvement, progress, innovation and creativity. They place value on effort and attempting difficult tasks. They view errors as part of the growth process and as informational. They view competence as developing through effort. Students with performance goals, on the other hand, define success as high grades and better performance than other students. They place value on avoiding failure and view errors as evidence of their lack of ability or worth. They view competence as inherited and fixed. As Ames and Archer (1988, p. 261) note, students with learning goals direct their effort to learn something new while those with performance goals strive to get high grades and perform better than others.

According to Dweck (1986), adaptive parents of achievement behavior are characterized by seeking challenges, pursuing task mastery, and persisting despite difficulties and obstacles. Maladaptive patterns of achievement behavior are characterized by avoiding challenges and withdrawing when faced with difficulty. Students displaying these maladaptive patterns tend to experience anxiety and negative "self-talk" when confronted by obstacles. While both types of students may not differ in intellectual ability, their patterns of behavior can have profound effects on their academic achievement. How does a student develop such adaptive academic behaviors?

To explore the process of the development of students' goals, we believe it is important to examine preservice teachers' responses to questions about their experiences of learning mathematics and of teaching it during their internships. In particular, we wanted to know whether they promote performance or learning goals when teaching mathematics. Do preservice teachers stress that their students get the correct answer or do they focus on the process of problem-solving? What do they think it means to be a "good" mathematics teacher? Is a "good" mathematics teacher one whose students are creative, or one whose students have high scores on standardized measures? With a strong emphasis on achieving high grades to get into university and to be awarded scholarships, is our educational system encouraging students, including preservice teachers, to develop performance goals? If preservice teachers have performance goals for themselves, will they inevitably "pass" those on to their students, thereby teaching them they are mathematics?

There is, in fact, considerable research evidence that situational demands can affect the salience of specific goals. For example, when social comparison has been made salient, students have focused on ability, and these self-perceptions have mediated performance and affective reactions to success and failure. By
contrast, when absolute standards, self-improvement, or participation have been emphasized, students have focused more on their effort and task strategies (Annes & Arcter 1988, p. 200).

In terms of students’ goal development, the teacher plays a major role in creating “situational demands,” or put another way, setting the classroom culture. We wanted to know the role of the cooperating teacher in preservice teachers’ development of teaching goals. The next part of the paper explores the role of the cooperating teacher, preservice teachers’ internship experience, and what beginning teachers value as meaningful in teaching mathematics.

Preservice Teachers’ Views on their Cooperating Teachers

Do preservice teachers model their teaching approaches after those of their cooperating teacher? Richardson-Koehler’s (1988) study found that “cooperating teachers felt that the strongest influence (both positive and negative) on their learning to teach was their student teaching experience” (p. 30). Implicit within this influence, however, is it also possible that preservice teachers find themselves immersed in non-negotiable power relations (Brintman, 1991).

One of the questions we asked preservice teachers who had recently completed their 12-week internship was: Did you ever sit in a math class, observing during your internship or as a K-12 student, and say to yourself “if I was teaching this I would do it another way”? To this question, some of the preservice teachers stated they would have had made the lesson more “relevant,” with more “real-life situations,” and ideas that “would have more of an impact on students.” Some said they wanted the lesson to be more “interesting and fun,” “exciting,” and “enjoyable for the students.” Other comments relating to a desire to teach another way included:

- Notebook work has to be done, but it should not be the basis for the whole year. Teachers need to find alternate ways to teach to make it more exciting.
- More discovery and freedom to develop own approach.
- I’ve watched (been in) classes where the teacher explains a topic and then assigns questions, and that’s it. I don’t think that’s effective.
- My co-op teacher taught math using mad minutes (timed tests) and workbooks as staples. To her credit though, she had a math mentor in order to change some of that.

The preservice teachers appeared to want classroom activities that were motivating, maximizing opportunities for learning, and promoting meaningful learning. It is important to note, however, that some preservice teachers reacted more positively to their cooperating teacher’s methods of instruction.

- But - there were also many times when I thought - Wow! What a great approach or idea.
Most preservice teachers agreed with the statements My cooperating teacher seemed to know a lot about math and My cooperating teacher seemed to enjoy teaching math.

When asked How was this demonstrated, “She told me so!” stated one preservice teacher. The respondents noted the cooperating teachers’ enthusiasm, enjoyment, varied activities, use of manipulatives, and involvement of students in classroom discussions as was illustrated by one comment:

- She loved it. She made math come alive and seem practical. All of the students loved math!

According to preservice teachers’ responses, cooperating teachers generally took an interest in finding new, creative and exciting ways to teach mathematics. Of the preservice teachers surveyed, four did not agree that their cooperating teachers enjoyed teaching mathematics. Their responses included:

- No experimentation of a concept - just chalkboard approach
- Negative comments; “I will pass this off on you.”
- Seemed to be a low priority, often “bumped” for other reasons

Most preservice teachers also agreed with the survey statement: My cooperating teacher offered encouragement and support regarding teaching math. The preservice teachers commented that their cooperating teachers would “tweak” activities, encourage, offer support, provide excellent feedback and suggest ways to improve. The preservice teachers also mentioned that their cooperating teachers modelled new ideas, and shared resources.

Overall, it appeared that the cooperating teachers were supportive and available as a resource and or guide. However, when one preservice teacher tried using The Geometer’s Sketchpad with students, the cooperating teacher “was excited initially... but seemed put off with it when the students were challenged.” Another respondent stated: “I found that only traditional approaches were used. So it was difficult to gain new ideas.” From these last comments, it seems that a few cooperating teachers were willing to allow preservice teachers to try new things but they did not want them to stray too far from the textbook and traditional performance goals. Does this suggest a pedagogic struggle between learning goals and performance goals as indicated by cooperating teachers’ support (or lack thereof) of risk-taking in the mathematics classroom? If a pedagogic struggle exists, what are the possible implications for preservice teachers? Bresman (1991) suggests that:

The experience of student teaching means entering a preestablished territory and negotiating for power within that territory. And in the case of student teachers, without permission and encouragement to carve out their own space,
Preservice Teachers’ Views on their Internship Experience

Most of the preservice teachers agreed with the statement I enjoyed teaching math. One respondent stated: “I felt unsure of the best way to help the students understand the topic but enjoyed when they understood.” This preservice teacher appeared to place a high priority on identifying and using learning strategies that promoted the comprehension of course material but did not indicate what she meant by student “understanding” and how she knew when students “understood.” This issue is discussed in greater detail in the section on meaningful experiences in/and knowing mathematics.

Another preservice teacher stated “I found it frustrating. Students came with the expectation that they would fail. Some had very low math skills. I would say 20% of my grade 9’s had no clue of what 5 - 3 was. Too many kids to help at once.” Is this preservice teacher referring to students who have given up because they viewed their performance as being unlikely to lead to success? Were these secondary students beyond the point of being satisfied with putting more effort into learning since they believed their performance would only lead to failure? Could it be that this preservice teacher is encountering students with performance goals rather than learning goals?

One preservice teacher tried to sidestep a structured workbook approach during his/her internship by avoiding a learning strategy that encouraged rote learning. “I didn’t feel like I taught it [math]” she said. What does it mean to feel like (or not feel like) having taught mathematics? What role does a person’s mathematical background play in “feeling” like they taught mathematics? Are they concerned with transmitting knowledge (which in turn sets a classroom culture promoting students’ development of performance goals) and corresponding evidence of this transmission? Responses to other survey statements suggest their emphasis is on performance. For example, two responses to the statement I gave my students a lot of choice in math class were:

- They had small choices - but I mostly dictated the activities they did.
- Most students did the same thing at the same time.

The students seemed obligated to participate (all at once) in the same station work, doing the same assignments, using the same resources. These actions also seem to suggest that while they may sometimes talk about learning goals, these preservice teachers do not always “walk the talk.”

Preservice Teachers’ Views About the Future

To understand more about our participants’ ideas and plans for teaching, we asked them: How do you see yourself teaching math when you get your first teaching position?
• I think I’ll be using lots of manipulatives and trying to relate it [math] to real-life experiences.
• A lot better now that I had a co-op who loved math. I want to do a good job and make it fun.
• The same way I taught during internship.

The preservice teachers expressed that they wanted to be “positive,” to show “patience,” and to “do a good job and make it fun.” Also mentioned by the preservice teachers were using hands-on activities, lots of manipulatives, and a variety of games/activities. There would be learning centres, stations, “various old and new methods,” “individual and group activities,” and “not just textbook assignments.” The tasks these preschool teachers described imply a desire to promote intrinsic motivation, to maximize students’ opportunities for learning, and to promote comprehension of the mathematics curriculum.

The preservice teachers appear to have learning goals for their students but will they become more concerned with performance goals—their students’ as well as their own—as they encounter time constraints in addressing curriculum content? While some preservice teachers seem to acknowledge that competence develops over time through practice and effort, it still appears that their approach encourages performance goals:

• concerning myself with getting through the curriculum. Doing 3 “inevitable” projects per year per subject & then mostly drill & practice. I will definitely have a set everyday.
• Depends on [the] grade. I believe it is important for students to both learn math facts (memorize) but also play with math to understand the theories
• …combination of seat work plus exploration

If preservice teachers could see themselves teaching what would they say about their own teaching? What would their observations regarding learning and performance goals? Will their own experiences as students become the deciding factor when it comes to performance and learning goals? Perhaps particular mathematical situations that held special meaning for the preservice teachers might shed some light on these questions. Reading, and reflecting on, preservice teachers’ meaningful experiences and their perceptions on what it means to know mathematics might tell us more regarding these questions.

**Meaningful Experiences in and Knowing Mathematics**

As teachers, it is always intriguing to discover how certain classroom experiences hold more meaning than others in our beginning experiences of teaching. Asking preservice teachers to think about the meaningful experiences reveals a great deal about what teachers think about and value in teaching. In our survey, we asked preservice teachers: **Describe a particular mathematical situation during your internship that held special meaning for you.** Several responses are shown below.
• We had a Science Olympics and it was great to see students use math and not think about it being math.
• A student who was struggling with math showed considerable improvement.
• Teaching the students to subtract and seeing their progress.
• The kids playing games and “getting it.”
• When my grade twos finally caught on to the concept of “time.” It was like I turned on a light switch: they all of a sudden just “got it.”
• After I had been teaching strategies for adding, it was neat to see my grade ones understanding and able to show my coop teacher what I had taught them.
• Having my students finally GET making change.

While there were additional responses given on the surveys, the responses listed above seem especially significant to us. Earlier in this paper, we stated that students with learning goals define success as improvement, progress, innovation, and creativity. Contained within the responses above are expressions like “use math,” “considerable improvement,” and “progress,” thus indicating that some of the preservice teachers use the language of learning goals when describing meaningful teaching experiences. We are left wondering, however, whether the use of the language of learning goals actually masks underlying performance goals. That so many preservice teachers used terminology like “get it” in explaining their students’ learning experiences begs the question of how a teacher may know when her/his students actually reach the point of “getting it” in their learning, and what exactly they are getting (Nolan & Corbin-Dwyer, 2002).

Before discussing the implications of the previous responses in more detail, it is worthwhile to present responses from another survey question in which participants were asked: What does it mean to you to “know” math?

• To be able to do the drill and practice problems which the students will be doing. Understand to a certain extent where it is going.
• I don’t think that people really “know” math. It’s something you experience all the time.
• To know how to put math to work in your everyday life.
• To have an understanding.
• To not be afraid of it. To approach it with confidence and not be reluctant to try.
• To feel comfortable in different situations that involve math without feeling dumb.
• It means that you not only know how to do it, but you understand how and why you do it (deeper understanding).
• To understand and be able to apply the knowledge to other situations.
• To understand the concepts and purpose behind doing math.
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- Feel confident using it in everything everyday.
- To find a way to make math make sense to you.

As can be seen from this selection of responses, the frequent words used to describe "knowing" in mathematics include understanding, purpose, ability to apply, have confidence, make sense, how and why. It is interesting to explore the relationships between this question on knowing and the question on meaningful experiences. From the question on most meaningful experiences, one can observe that preservice teachers' responses were dominated by comments directly relating to their own ideas of what it means to know. In other words, their most meaningful experience was often related to an experience in which they somehow "saw" their students reach an understanding. This generates at least two important questions: What does it mean to understand? Is it possible for a person to sense another person's understanding? To understand is defined as: "to get the meaning of" (Avis, Gregg, Scargill, & Courtney, 1991, p. 1305). Additionally, to understand can be defined as "to realize; to know the feelings and thoughts of" (Nichols 1994, p. 274). Given these definitions, it appears that the act of understanding is an inner process. Noddings and Shore (1984) closely associate understanding with intuition.

Understanding is not properly attributed to the recitation of steps in a proof, no matter how perfectly the steps unfold from premise to conclusion, but to the "seeing" that occurs when the products of reason are re-examined—looked at—by intuition for the purpose of discerning or creating meaning (p. 53).

According to Noddings and Shore, a further sign that intuition and understanding are closely associated is in the realization that there is a feeling of excitement and anticipation in the quest for meaning and understanding. These authors also use the word "capture" (as opposed to "given") when conveying their ideas about the processes of understanding concepts.

This leads to the second question, and that is whether it is possible to sense someone else's understanding. There is much research and reflection on understanding what it means to understand (Lerman, 1998; Steinbring, 1998) and the concept seems complicated enough when it is directly related to one's own understanding. How is it possible that a teacher might actually detect understanding in her / his students? If understanding is based on "getting the meaning" and it is really about an internal quest, then perhaps a successful quest for understanding eventually arrives at insight.

It would be very interesting indeed if such a visual display of understanding on the part of the learner could signify a student achieving learning goals. If student insight was in sight for these preservice teachers, then it may be reasonable to attribute their language of "seeing students get it" as understanding. We are less optimistic, however. Following along the lines of the discussions thus far in this paper, we are inclined to believe that visual detection somehow relates to performance goals—a teacher's search for an external sign.
that encourages them and informs them that they have been successful in transmitting knowledge to their students. "It was like I turned on a light switch," one preservice teacher commented. "It was neat to see my grade ones understanding and [to be] able to show my coop teacher what I had taught them," commented another. While the actual visual "aha" belongs to the learner (or it quite likely should anyway), the teacher uses it as a sign that s/he has been successful and the students understand. So what does it mean, then, to reach an understanding in mathematics learning?

Lerman (1998) states that understanding is cumulative, fragmented, and incomplete. In his description of understanding as cumulative, he states:

It is cumulative in that it grows through learning experiences, and at every stage an individual can be said to understand, in that she or he can answer whatever is given within those particular learning experiences. Learning is goal-oriented, and the dominant goal for children in schools is to get the right answers to the questions set, in the shortest possible time (p. 303).

According to Steinbring (1998), mathematical understanding is the deciphering of both epistemological signs and symbols and social signs and symbols. By social signs and symbols, Steinbring means those signs and symbols related to the culture of the mathematics classroom, such as remarks, reinforcement, confirmations, rejections, etc. made by the teacher or other students. While acknowledging the process of deciphering to be a very difficult task, Steinbring asserts that the successful deciphering of the epistemological and social signs and symbols guarantees understanding (p. 345). The act of deciphering social signs and symbols, however, relates to what we perceive is a very problematic aspect of mathematics learning. That is, it is a common occurrence for students to be seen playing a guessing game as to what the teacher's intentions or goals are for the particular mathematical learning situation. This situation of guessing where the teacher wants to go often results in the teacher's a priori knowledge dominating the learning situation. The students just have to fill in the correct answers or responses for the scenario at hand—a scenario well rehearsed by the teacher. This implies that the teacher probably has performance goals in mind for her/his students. That is, the students have little opportunity for their own goal-setting; they learn to be motivated through approval comments by the teacher; they evaluate their own performance in relation to teacher's expectations and intentions (Örremark, 1998, p. 488).

It is crucial at this point to stress that this critique of a teacher's goals for her/his students does not mean that we believe mathematics teachers are providing experiences that are intentionally limiting. It is likely that the teacher's personal scope of understanding prevents students from being able to actively pursue personal learning goals. There is extensive research on teachers' abilities and experiences in creating the conditions for a constructivist learning environment, and much of the research points to the fact that it is difficult to teach in ways other than we were taught, especially if we experience anxiety or
lack of confidence in the subject area (Ball, 1990; Hill, 1997; Nolan, 2001). If teachers have experienced an environment that focuses on performance, rather than learning, goals, then it is quite likely this will be the environment that will seem natural for them to provide for their students. Teachers will look for visual cues that students have caught on to the approach being promoted. It is satisfying for the teacher to experience the success of teaching well and to see that the students “got it.” It makes sense that this learning “success” holds special meaning for them, especially as beginning teachers. Unfortunately, however, requiring the students to enter the teacher’s fixed methodological and epistemological framework could possibly prevent, rather than promote, student understanding. The deciphering of epistemological and social signs and symbols could become a game and the act of “getting it” could be related more to the teacher’s goals than the students’ goals in learning. In terms of the student’s quest for meaning and purpose on the path to understanding, it seems unfortunate that the meaning and purpose may lie in an extrinsic motivation for fitting into the teacher’s fixed framework. We do not mean to trivialize the process of “getting it” as expressed by these preservice teachers, but the significance lies in determining whether a teacher is promoting learning or performance goals in her/his students. Related to this distinction between performance and learning goals, von Glasersfeld (1995) states:

> From a constructivist perspective, learning... requires self-regulation and the building of conceptual structures through reflection and abstraction. Problems are not solved by the retrieval of rote-learned “right answers”. To solve a problem intelligently, one must first see it as one’s own problem. That is, one must see it as an obstacle that obstructs one’s progress toward a goal (p. 14).

Understanding is related to having a sense of purpose. Is the act of “getting it,” as visually detected by these preservice teachers, tied in with a student’s sense of purpose in learning (internal motivation) or a sense of purpose in performance (external motivation)?

**Critical Questions for Teacher Education**

While we acknowledge the weaknesses inherent in survey studies, particularly the challenges of language subtleties and communication barriers, it is possible that there is significance in our observations and curiosities about the language these participants chose to describe their experiences. We believe, therefore, that it is imperative to encourage preservice teachers to reflect on their beliefs about mathematics, including their use of language on what it means to know and to understand (in) mathematics. These reflections should not begin and end with their experiences of teaching mathematics during their internship, but must necessarily delve into their personal attitudes and beliefs about mathematics, acknowledging that they have evolved over many years as a student learning mathematics. Perhaps one of the best ways to discuss the implications of this
study for teacher education programs would be to reframe some of the critical questions asked throughout the paper. As with many challenging and perplexing educational questions, solutions and/or directions do not readily emerge simply because the questions have been identified or verbalized. Many of the questions relating to the performing or learning of mathematics have been posed by mathematics educators for quite some time. It is our belief, however, that significance rests in the opportunities created for acknowledging the voices of preservice teachers.

Conclusion

Included in our survey, and discussed in this paper, are several questions on which there must be considerable reflection and action within teacher education programs. If the nature of preservice teachers’ experiences is on performing in mathematics, can teacher educators expect them to understand and promote learning goals in their own mathematics classrooms? Because preservice teachers use the language of learning goals, does this indicate that they understand how to teach so that the focus is not solely on achieving high grades and performing better than others? How can teacher educators promote the use of reflective teaching practices so that preservice teachers do not merely embed learning goal language within performance goal teaching? If the nature of preservice teachers’ experience in the current educational system, particularly in university, is the rewarding of high grades and the use of comparative evaluation, are teacher educators being contradictory in their message of the importance of learning goals in the mathematics classroom? In other words, how can teacher educators help preservice teachers “walk the talk” in the teaching of mathematics? How do teacher educators promote a shift in thinking that does not emphasize a superficial understanding of student learning (only those who “get it”), an understanding that appears to fit our preservice teachers’ framework of what it means to know (in) mathematics? Teacher educators need to create the conditions for preservice teachers to ask the same kinds of critical questions as we have in this study of their own past experiences and of their futures as mathematics teachers.

References


