Learning mathematics while learning to teach: Mathematical insights prospective teachers experience when working with students

Subject matter understanding is indisputably one of the essential knowledge domains for teaching mathematics. Yet, it is widely known that elementary prospective teachers enter teacher education programs with a weak background and understanding of the mathematics they are preparing to teach. They are also known to have had negative experiences as students and consequently have low self-confidence or a negative disposition towards learning more mathematics. A question mathematics teacher educators are constantly facing is how to help prospective teachers learn more mathematics while they also learn about teaching and learning. The goal of this paper is to address this question by examining the ways in which elementary prospective teachers might learn more mathematics through the study of mathematical pedagogy.

Theoretical Framework

This paper is framed by studies of prospective teachers' knowledge and beliefs (e.g., Ball, 1990a,b; Holt-Reynolds, 1992; Simon, 1993). It is also framed by the literature on teacher socialization (e.g., Feiman-Nemser & Buchman, 1986; Zeichner & Gore, 1990), and the research on the impact (or lack thereof) of teacher education initiatives (e.g., Borko, Eisenhart, Brown, Underhill, Jones, & Agard, 1992). It further draws on the literature of teacher education practices framed within a situated cognition view of learning to teach (e.g., Lampert, 1985; Schon, 1983).

The typical structure of teacher education programs seems to assume that learning mathematics occurs prior to learning mathematics pedagogy. In most teacher preparation programs, mathematics courses are typically taught independently of pedagogical concerns. Mathematics education courses, in turn, tend to place mathematical inquiry in the background while focusing on the theories and methods of teaching and learning. Research, however, suggests that neither of these structural arrangements have been very successful in helping preservice teachers construct interconnected knowledge of mathematics and mathematical pedagogy (see Brown & Borko, 1992). That is, even though preservice teachers may extend their mathematical understandings, they do not necessarily translate this understanding into pedagogical practice. The construction of mathematical understanding, on the other hand, is very difficult to promote in courses which focus on instructional methods and practices (Simon, 1994).

Such results or lack thereof, however, are not surprising when considered from the perspective of learning in authentic contexts of practice (see Brown, Collins, & Duguid). Current teacher education practices, however, have become responsive to the idea of learning through engagement in authentic teaching activity. Course-related field experiences have, for instance, become more popular and often take the form of classroom observations, interviews with students, and even teaching episodes. These field-related assignments, however, are often thought of as opportunities to develop prospective teachers' pedagogical content knowledge. A reasonable question to ask, in light of the issues discussed, is how can such experiences be also construed as opportunities to study and investigate subject matter?

Data Sources and Analysis

To explore the question of how field-related experiences could become occasions for prospective teachers to study and investigate mathematics I draw upon data of my own teaching of elementary mathematics methods. For the past five years I have incorporated different kinds of field-related experiences into the mathematics methods courses I teach. In this paper I focus on three types of interactive field-related experiences I have offered at one time or another to my
preservice teachers: (a) a mathematics letter writing exchange, (b) a mathematical interview, and (c) a teaching session.

The reports preservice teachers write about their experiences with students are used to probe the depth of their developing understanding and dispositions towards mathematical inquiry. The data of six preservice teachers with contrasting experiences are used to describe and analyze typical orientations towards mathematical investigations I have noticed. For each one of the three field-related contexts mentioned, the experiences of two preservice teachers are described and analyzed with regards to their reactions to and reflections about the puzzling mathematical situations they encountered when working with students. For the purposes of this paper I will only discuss work that is related to the topic of fractions.

In addition, further data collection is currently under way as part of a “teaching experiment” I am conducting to further examine the question raised in this paper. This term I have explicitly asked my preservice teachers to keep a journal of mathematical insights. This journal has been defined as a notebook for collecting mathematical insights experienced during regular on-campus classes, field visits, work with students, readings, and independent study.

**Results**

In the context of their interactive experiences with students, I have found that prospective teachers in my mathematics methods courses have engaged in mathematical explorations of their own. These explorations have typically occurred in the following contexts: (a) when selecting and preparing to pose mathematical questions; (b) when analyzing students' work, particularly when dealing with students' incorrect work; and (c) when providing mathematical explanations to students' initiated questions. Although this has been the case for a great majority of my preservice teachers, their reactions and handling of puzzling mathematical situations vary greatly. I will illustrate this point with two opposing examples from Thea and Terry in the context of their letter exchanges with fourth graders. (More elaborate examples will be provided in the actual paper).

Thea encountered a puzzling mathematical question when she was helping her student figure out “how to tell whether or not one fraction is bigger than another.” Initially her student thought that the fraction with the bigger denominator was the biggest fraction. Thea used drawings (as opposed to symbolic manipulation such as finding a common denominator) to show the student that this was not the case. In her response, Thea's student used drawings to show that the fraction with the largest denominator was actually bigger by drawing two different sized wholes for the given fractions. Faced with this puzzling work, Thea realized that in her explanation it was assumed that the two fractions were parts of the same or equal sized wholes. Further analysis of this led Thea to ask an important mathematical question, What happens when you compare fractions which belong to unequal-sized wholes? This work led Thea to later make an important mathematical discovery, that “when you use common denominators to determine which fraction is bigger you are ensuring that each ‘whole’ is the same size.”

Terry also received interesting responses from her student. She sent a page with eight 4x6 (dotted grid) rectangles and asked her to “divide them into 1/4 in as many ways as possible”. Her student replied by sending not only a few typical drawings for 1/4, she also sent unusual partitions (equal size but different shapes) for that fraction. In addition, the student asked whether such uneven shapes were allowed. In another occasion, Terry asked her student to solve a textbook-like exercise for adding fractions (1/2 + ___ = 1). Terry's student replied with not only the correct
answer, but provided 6 different fractions that could fit the number sentence (1/2, 2/4, 4/8, 8/16, and 16/32). The student further said: “I think you might just have been wanting the first one though.” Terry's reaction, however, was quite different from Thea's. While Thea explicitly raised questions about the mathematics in her students' work and continued to investigate it, Terry made no further attempts to investigate the questions the student raised and did not provide a response to her student's query in her response letters.

From the teacher development perspective (see Brown and Borko, 1992) the explanation for why prospective teachers like Thea seem to be more naturally inclined to reflect and investigate puzzling episodes in her teaching have to do with their level of development and concern as learners of teaching. According to developmental theories of knowledge growth of teachers, prospective teachers move through stages of development and concerns which explains why they attend to certain things and ignore others. It may be possible that concerns for their own understanding of the subject matter is not high in the priority list of preservice teachers like Terry. A different perspective, however, which takes into consideration the context and structure of the task these preservice teachers were asked to perform, in turn, suggests that the explanation lies in the inexplicit nature of the task. Studies of structural constraints in tasks posed to prospective teachers often report this to be the case (e.g., Richert, 1992). It is plausible that if a more explicit structure for investigating mathematical insights were provided, everyone would have shown an “inclination” to do so. The “teaching experiment” I alluded to earlier has been designed to illuminate this issue. Results from this data will also be included in the actual paper.

References


