A Self and Peer Assessment Intervention in Mathematics Content Courses for Pre-Service Elementary School Teachers

Xin Ma, Richard Millman, Matt Wells
University of Kentucky

Introduction

We explored in the present analysis the use of assessment in mathematics content courses for future elementary school teachers. At most institutions in the United States, these courses are taught by mathematicians whose emphasis is on learning or relearning the mathematics rather than pedagogical implications of mathematical knowledge, usually as a direct result of the disconnection between mathematicians and mathematics educators. These courses are typically found to be difficult by a large percentage of students for whom mathematics is a major hurdle in their teacher preparation programs. One intervention strategy to tackle these concerns is to infuse assessment into mathematics content courses. As a project of collaboration between the departments of mathematics and education, we explored this idea in two ways, self assessment and peer assessment. We involved students in self assessment of their procedural knowledge, conceptual knowledge, and problem solving, by asking them to define the terms in their own language and identify from their own experiences each type of knowledge. Through the addition of a required oral mathematics presentation, we also engaged students in peer evaluation of other students by asking them to rate the quality of the presentation from multiple perspectives.

Targeting pre-service elementary teachers, we attempted to use the results of this intervention to explore (a) whether there is any relationship among understanding of procedural knowledge, conceptual knowledge, and problem solving, (b) whether there is any factor structure of understanding of procedural knowledge, conceptual knowledge, and problem solving, (c) whether self assessment of understanding of procedural knowledge, conceptual knowledge, and problem solving impacts gains in mathematics performance (in a pre- and post-test design), and (d) whether peer evaluation of oral mathematics presentations impacts understanding of procedural knowledge, conceptual knowledge, and problem solving.

Review of Literature

Teachers' professional knowledge of subject matter (e.g., mathematics) consists of two overlapping domains: subject matter knowledge and pedagogical content knowledge (Borko et al., 1992). We focused on the former in the present study, because we worked with pre-service

elementary teachers in mathematics subject matter courses. The literature on subject matter knowledge of pre-service teachers suggests that they typically enter teacher education programs with the narrow conceptions of mathematics as a set of rules and conventions (Quinn, 1997). What is lacking in the literature is what subject matter knowledge structure, in terms of conceptual and procedural understanding of mathematical knowledge, pre-service teachers bring into their teacher education programs. In considering pre-service teachers' subject matter knowledge structure, we also added understanding of problem solving in mathematics (NCTM, 2000).

To better prepare pre-service elementary teachers, reform of college-level mathematics courses is needed (Ball, 1990). One of the most effective ways is to relate to or emphasize the teaching aspect in college-level mathematics subject matter courses (Mathematics Sciences Education Board, 1996). Our intention was to create awareness and appreciation for the notion of classroom assessment early in pre-service elementary teachers' education programs, instead of waiting until they take (pedagogical) method courses to get to know this aspect of teaching. The infusion of assessment is also a natural companion of instruction in mathematics as one of the principles of the NCTM.

Setting and Method

The present intervention was carried out during the 2005-2006 academic year at one of the major universities in the Southern part of the United States. Every year, about 375 pre-service elementary (90%) and middle (10%) school teachers enroll in a mathematics content (subject matter) course designed for majors in elementary and middle level education programs based on the textbook entitled *Mathematical Reasoning for Elementary Teachers* (Long & DeTemple, 4th edition, 2005). As one major component of the course, an oral presentation is closely related to the notion of infusion of assessment. The goals of this exercise emphasize the quality of the understanding and interpretation of mathematics based on the NCTM standards. Pre-service elementary teachers were given a wide range of subjects and could choose the topics on which they were interested in presenting. Groups were then constructed based on the choices of topics. Each presentation was evaluated for (a) quality of the oral presentation as a presentation, (b) preciseness and mathematical correctness, (c) applicability (relating the material to what would be expected to be seen in the elementary classroom), (d) creativity (bringing

something to the presentation other than what was in the article or book), and (e) group work (collaboration).

Each oral presentation was accompanied by a peer mentor assessment assignment. We used peer assessment data to address our research question (d). As another infusion of assessment into mathematics content (subject matter) courses, self assessment on the understanding of conceptual knowledge, procedural knowledge, and problem solving was also implemented early in the course. After receiving results of their exams, pre-service elementary teachers were asked to reflect on their tests and then do a self assessment accordingly. We used self assessment data to address our research questions (a) to (c).

Summary of Principal Findings

The present study aimed to explore the knowledge structure of pre-service elementary teachers as they configure understandings of conceptual knowledge, procedural knowledge, and problem solving. Based on self assessment data, two factors emerged from our factor analysis: procedure dominated knowledge and problem solving dominated knowledge. In contrast, there was no evidence for the existence of unique (or distinct) conception dominated knowledge among pre-service elementary teachers. Therefore, their understanding of conceptual knowledge was part of or confused with their understanding of procedural knowledge and problem solving. We found that the two factors were equally important in the knowledge structure of pre-service elementary teachers. Therefore, there was a balanced understanding of procedural knowledge and problem solving as separate factors in the learning of mathematics among pre-service elementary teachers.

The present study also aimed to connect understandings of conceptual knowledge, procedural knowledge, and problem solving with gains in mathematics achievement and with the quality of oral mathematical presentations. We found that understanding of conceptual knowledge, procedural knowledge, and problem solving did not have appreciable effects on gains in mathematics achievement during the mathematics content (subject matter) course (the context for this intervention). In contrast, based on self and peer assessment data, we found that group work was associated with improved understanding of procedural knowledge, and preciseness and mathematical correctness and creativity were associated with improved understanding of conceptual knowledge. Finally, although some pre-service elementary teachers might be good at conceptual thinking and reasoning (in connection with conceptual knowledge),

they did not necessarily communicate effectively either mathematical knowledge or mathematical thinking to their peers.

Discussion

One of the most striking findings from the present study is that pre-service elementary teachers did not have a concept domain in their mathematical knowledge structure. It is easier to approach conceptual understanding from a procedural perspective [Skemp]. Our results also suggest that pre-service elementary teachers could approach conceptual understanding from the perspective of problem solving. It seems to us that, most likely, when conceptual knowledge was applied to problem solving by pre-service elementary teachers, knowing "how" overweighed knowing "why." In both cases, pre-service elementary teachers demonstrated seriously inadequate appreciation of conceptual knowledge especially with regard to its difference to both procedural knowledge and problem solving. Results of the present analysis provide further support for the argument that reform on mathematics content (subject matter) courses at the college level must emphasize a conceptual approach to mathematical knowledge.

We were intrigued by the lack of relationship between understandings of conceptual knowledge, procedural knowledge, and problem solving and gains in mathematics achievement among pre-service elementary teachers. This disconnection indicates largely one thing to us—knowing what a procedure is does not necessarily mean knowing how it is applied or used to make connections. We believe that practice is very likely one of the major reasons. Although good arguments can be made against drills in mathematics (and we certain agree), we still believe that knowing mathematics requires considerable time commitment.

Finally and most importantly, results of the present study do suggest that the infusion of assessment into mathematics content (subject matter) courses holds great potential to strengthen mathematical understanding among pre-service elementary teachers. We were particularly encouraged by the finding that the level of the oral mathematical presentation was associated with aspects of conceptual understanding or knowledge.

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Dr. Xin Ma: Department of Curriculum and Instruction, xin.ma@uky.edu

Dr. Richard Millman, Mathematics Department and Department of Curriculum and Instruction, millman@ms.uky.edu

Mr. Matt Wells, Mathematics Department, mwells@ms.uky.edu

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