Fall 10-19-2012

Problem Solving Abilities and Perceptions in Alternative Certification Mathematics Teachers

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SECONDARY MATHEMATICS ALTERNATIVE CERTIFICATION TEACHER PROBLEM SOLVING

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Abstract

The purpose of this study was to understand alternative certification middle and high school teachers' mathematical problem solving abilities and perceptions. Participants were given a problem solving examination and required to reflect upon their students' and their own problem solving. Findings revealed there was a significant improvement in problem solving abilities for the teachers over the course of the semester, and there was a direct correlation between content knowledge and problem solving ability. Teachers perceived their students' problem solving abilities as generally weak due to not understanding how to start a problem, lack of persistence, and poor literacy skills.

Introduction

Problem solving continues to be of high importance in mathematics education (Posamentier & Krulik, 2008; Posamentier, Smith, & Stepelman, 2008) and is one of the five National Council of Teachers of Mathematics (NCTM) process standards (NCTM, 2000). National Council of Supervisors of Mathematics (NCSM) has considered problem solving to be the principal reason for studying mathematics (NCSM, 1978), and it has been recommended that mathematics content be taught from a problem solving perspective (NCTM, 2000; Schoenfeld, 1985).

In order to understand what problem solving is, first the definition of a mathematical "problem" must be understood. Charles and Lester (1982) defined a mathematical problem as task in which (a) The person confronting it wants or needs to find a solution; (b) The person has no readily available procedure for finding the solution; and (c) The person must make an attempt to find a solution. According to Krulik and Rudnick (1989), problem solving is a process in which an individual uses previously acquired knowledge, skills, and understanding to satisfy the demands of an unfamiliar situation. Polya (1945), in his seminal work *How to Solve It*, outlined a general problem solving strategy that consisted of (a) Understanding the problem; (b) Making a plan; (c) Carrying out the plan; and (d) Looking back.

The purpose of this study is to understand alternative certification middle and high school mathematics teachers' problem solving abilities and perceptions about their students' and their own problem solving, which is critical in supporting them to teach from a problem solving perspective. NCTM (2000) said, "Problem solving is not only a goal of learning mathematics but also a major means of doing so" (p. 52).

Theoretical Framework

In mathematics education, problem solving is the manifestation of constructivist learning, the theory that students learn best through constructing their own knowledge, as promoted by thinkers such as Jean Piaget and John Dewey. Authentic problem solving in mathematics is the basis of reform- and inquiry-based instruction in mathematics (Clark, 1997).

There has been limited research conducted on problem solving from teachers' perspectives (Chapman, 1997; Xenofontos, 2007). It has been shown that teacher beliefs about student ability greatly influence instructional practices (Nathan & Koedinger, 2000). Asman and Markkovits (2009) found teachers who are unable to solve difficult non-routine problems were

less likely to include these types of problems on student assessments, even if they were willing to address such problems in their instruction. Polya (1945) laid the groundwork for systematic approaches to solving mathematical problems, and NCSM (1978) and NCTM (2000) have emphasized problem solving as the purpose of mathematics instruction and a way of teaching.

Research Questions

1. What differences were there in problem solving abilities between the beginning and end of the semester in a mathematics content course for alternative certification teachers?
2. What were teacher perceptions of their students' and their own problem solving abilities? Further, what differences in perceptions of student and their own problem solving abilities existed between the beginning and end of the semester in a mathematics content course for alternative certification teachers?

Methodology

The methodology of this study involved quantitative and qualitative methods. The sample consisted of 34 new teachers in the New York City Teaching Fellows alternative certification program enrolled in a graduate algebra content mathematics course for teachers that involved rigorous derivations and proofs. Teachers were given a problem solving examination at the beginning and end of the semester. Additionally, teachers were required to reflect upon both their students' and their own problem solving at the beginning and end of the semester.

Results

The first research question was answered using scores from the problem solving examination, and data were analyzed using paired samples *t*-test (see Table 1), which revealed a statistically significant difference between pretest scores and posttest scores for the problem solving examination, and there was a very large effect size.

Table 1

Paired Samples t-Test Results for Problem Solving Ability

Problem Solving Examination	Mean	SD	*t*-value	*d*-value
Pretest	4.91	1.654	-8.679**	2.08
Posttest	8.35	1.649		

$N = 34$, $df = 33$, two-tailed

** $p < 0.01$

The second research question was answered using teacher reflections analyzed to determine teacher perceptions of student problem solving as well as their perceptions of their own problem solving. At the beginning of the semester teachers categorized their students as having weak problem solving abilities and skills. The most commonly reported problems were knowing how to get started and persistence. Teachers said many students did not understand the problems they had to solve. At the end of the semester teachers found many of the problems they encountered with their students in the beginning of the semester still persisted. Teachers felt there were several things they could do to help improve their students' problem solving abilities and skills. Most commonly mentioned were the steps to problem solving as outlined by Polya (1945). Teachers commonly said that scaffolding and differentiated instruction could be used to help improve problem solving in their students.

At the beginning of the semester teachers reported that they shared many of the issues that their students have such as knowing how to start, persistence, understanding what the problem is asking. At the end of the semester, most teachers said that having the algebra content class that focused on derivations and proofs had improved their problem solving abilities greatly. Several used the phase, "I have come a long way," referring to their problem solving abilities.

Many said that it was the analytic nature of derivations and developing proofs that helped improve their problem solving abilities. Additionally, many found understanding how mathematics "works" in the class furthered their analytic skills.

Conclusions and Educational Implications

Since there was an increase in problem solving abilities over the course of the semester it can be argued that the a strong mathematics requirement for alternative certification mathematics teachers, combined with their own teaching experiences, can lead to stronger problem solving skills, which is important given the emphasis of teaching mathematics from a problem solving perspective (Clark, 1997; NCSM, 1978; NCTM, 2000; Posamentier et al., 2008). Future research should examine how much of this has to do with content classes for teachers or their teaching experience, particularly in alternative certification programs.

Teachers perceived that students did not persevere in their problem solving because they were reliant on the teacher giving them the solutions in previous years. While this reliance on teachers providing solutions may be partially due to negative attitudes toward problem solving held by the students (Arslan & Altun, 2007), it also could be a problem with teachers not giving enough time for students to engage in problem solving. This reinforces the need to give students more time in their problem solving, and to resist the temptation to simply "give" the solutions to the students. The results of this study provide further evidence for the need and recommendation for teachers to increase the amount of time students have to solve problems.

One teacher said when he had time to work with one student individually he found great improvement in the student's problem solving skills. Individual student attention is important to improving student learning (Foote, 2009; Himley & Carini, 2000). In recent years state and local governments have been reducing school budgets, which led to high student to teacher ratios. It is

recommended that funding be made available to ensure that students receive the proper individualized attention in their mathematics classes, which could improve their problem solving skills and improve mathematics achievement in general. Further research should examine the impact of more individualized attention on problem solving.

Strong problem solving abilities and skills are essential not just in mathematics, but in other subject areas and life in general. It is important that teacher educators be aware of their pre- and in-service teachers' problem solving perceptions both for the students and the pre- and in-service teachers themselves. This is especially true for the many teachers who come to the profession through alternative pathways who increasingly teach in high-need urban schools. It is important that the students in high-needs schools receive the critical thinking and problem solving preparation that they need for success in life.

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