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THE IMPACT OF ADDITIONAL CONTENT COURSES ON TEACHER CANDIDATES' BELIEFS REGARDING MATHEMATICS CONTENT AND PEDAGOGY

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Abstract

Alarming studies indicating a lack of mathematical knowledge among elementary educators has led to increases in the number of mathematics courses required in teacher preparation programs. This study examines the impact newly required mathematics courses had on teacher candidates' beliefs regarding mathematics content and pedagogy in a large, southeastern teacher preparation program. A survey instrument was used to compare perceptions of teacher candidates required to take additional mathematics courses to those who were not. Differences in perceptions between groups were found. Factors possibly contributing to the findings of this study as well as suggestions for further research are discussed.

Introduction

In efforts to improve student achievement in mathematics and meet the mathematical literacy demands of an advancing technological society, a continual need exists to reform mathematics teaching and learning (Riordan & Noyce, 2001). Repeatedly, studies comparing students in the United States to their international counterparts have indicated that our students are performing below their international peers in various mathematics content areas (TIMSS, 1997; TIMSS, 1999). Studies which have investigated the teaching practices of Japanese, German and U.S. teachers suggest that differences in teaching practices contribute to international students performing better in mathematics than their U.S. counterparts (Geist, 2000; Learning First Alliance, 1998).

According to the National Science Board (1999), updating current teacher knowledge is essential, and improving teacher preparation programs is crucial to developing world-class mathematics instruction in the United States. Changing the practices of teachers however, is no simple task. Since the launch of Sputnik in the 1950s, ongoing efforts have been made to improve mathematics education in the United States and still there is much to be done (NCTM, 2000). According to the National Council of Teachers of Mathematics (2000), the effectiveness of mathematics education in our nation can be improved substantially. Improving practice can be very challenging due to the many situational, personal, and attitudinal variables which exist that influence the behaviors of classroom teachers. A teacher's attitudes and beliefs, the student population, the type and extent of materials and resources available, and the school environment are among the many different factors that can either positively or negatively influence the practices of a teacher. The relationships among these variables are so complex that in spite of having volumes of research conducted over several decades, recommendations for additional research still exists (McLeod, 1989; Peterson, Fennema, Carpenter, & Loef, 1989).

Among the most researched factors that influence instructional practices of mathematics educators are teachers' belief systems. The conceptions, values, and ideology that constitute a teacher's belief system are thought to have a significant impact on mathematics instruction (Earnest, 1989). In the last two decades, research documenting the impact of teacher beliefs on mathematics instruction has grown considerably in many directions (Raymond, 1997). Strong links have been found between teachers' beliefs, knowledge, and judgments, and the way they teach mathematics (Peterson, et. al, 1989). Beliefs about subject matter, including one's orientation to subject matter have been found to contribute to the choices teachers make in their teaching (Borko, 1992). Beliefs about students' abilities have been shown to greatly influence the instructional practices of mathematics teachers. Even the design of classroom assessments has been shown to be influenced by teachers' beliefs about mathematics (Nathan & Koedinger, 2000). A teacher's beliefs play a key role in governing instructional practices and as a result, research on teacher beliefs has remained an important theme in investigating mathematics teaching and learning (McLeod, 1989).

Teacher Beliefs and Methodology Courses

In teacher preparation programs, mathematics methodology courses operate as the primary mechanism for influencing teacher candidates' beliefs about mathematics pedagogy. It is in these methodology courses that future mathematics teachers learn about Piaget, Constructivism, and other tenants of mathematics pedagogy. Teacher candidates also learn about content specific instructional strategies and are given the opportunity to practice and reflect on those strategies.

In spite of the concerted efforts by instructors of methodology courses to influence students, the extent to which such coursework actually influences the beliefs or practice of teachers continues to be a matter of debate. Raymond (1997) found that preparation programs have had limited influence on the practices of the teachers after they graduate. In fact, teachers' beliefs about pedagogy were found to be influenced more by their own practices than by preparation coursework. When teachers did hold onto pedagogical beliefs learned in preparation programs, they did not reflect those beliefs in their practices (Raymond, 1997). Vacc and Bright (1999) found that even when methodology courses were able to yield significant changes in pedagogical beliefs, those changes in beliefs did not transfer into instructional practices. Ultimately, methods courses do not appear to successfully generate lasting changes in teachers' practices.

One possible explanation for the inability of methods courses to significantly impact the beliefs and practices of teacher candidates is that beliefs about mathematics content are more closely linked to instructional practice than beliefs about mathematics pedagogy (Raymond, 1997). Methodology courses primarily influence beliefs about pedagogy rather than beliefs related to content. As a result, even when methodology courses are successful at changing beliefs, the beliefs that most affect practice are not the ones changed. Additionally, beliefs about mathematics content are significantly affected by one's own experiences as a mathematics student (Conney, Shealy, and Arvold, 1998; Raymond, 1997). Based on this research, if preparation programs are to more effectively impact the practices of mathematics teachers, efforts would be better spent attempting to influence beliefs about mathematics content rather than beliefs about pedagogy. Furthermore, these efforts would best be integrated into content courses rather than methodology courses.

The Current Role of Content Courses

The importance of content courses in teacher preparation programs has increased as elementary teachers' deficiencies in content knowledge have become more politicized (Sanders and Morris, 2000). Studies such as the TIMSS have stated that U.S. teachers, particularly middle and elementary teachers, are not adequately prepared to teach mathematics and more content coursework is needed (Learning First Alliance, 1998). Widely accepted is the belief that content courses have the capacity to improve the ability of pre-service and in-service teachers to nurture mathematical understandings (Gitomer, Latham, and Ziomek, 1999; Swafford, Jones, & Thornton, 1997). The common idea here is that "a person cannot teach what he or she does not know" (Danielson, 1996, p. 62).

In the past, elementary education preparation programs' content courses were not a significant part of the preparation program. Typically, students majoring in elementary education took fewer content mathematics courses than students majoring in middle grades or secondary education. In most cases, the only mathematics content courses required to be taken by elementary majors were those specified in the core liberal arts curriculum (Learning First Alliance, 1998). The notion that good mathematics instruction begins with the mathematical knowledge of the teachers did not appear to apply to the preparation of elementary teachers and research exists that demonstrates that traditionally-prepared elementary teachers have deficits in content knowledge (Swafford, Jones, & Thornton, 1997; Sanders & Morris, 2000). These deficits have also been linked to deficits in student learning (NCTM, 2000; Sanders & Morris, 2000, TIMSS, 1997).

The Purpose of this Study

The purpose of this study was to investigate the impact taking three additional content courses concurrently with the methodology courses had on a group of elementary teacher candidates' beliefs regarding mathematical content and pedagogy. In the state of Georgia, the Board of Regents created initiatives to improve the content knowledge of elementary teachers by requiring students majoring in elementary education to take 12-15 semester hours of mathematics in addition to the mathematics courses included in the core liberal arts curriculum (Georgia Board of Regents, 1998). Nine of those concentration hours must be taken be at the junior and senior level during students' professional preparation courses. This study investigated whether beliefs about mathematical content in addition to beliefs about mathematical pedagogy were influenced by this alternative preparation program format. Research studies from the last 20 years on teachers' beliefs about mathematics have repeatedly stated the need for more research to be conducted in this area (McLeod, 1989). Given the links demonstrated between beliefs regarding mathematical content and instructional practice (Raymond, 1997), the findings of this study may prove valuable in designing more effective teacher preparation programs.

Methods

Participants.

The participants in this study were elementary education teacher candidates in their senior year, enrolled in a mathematics methodology course at a 4-year university in Southeastern United States. The 113 participants, consisting of five males and 108 females, were divided into two groups based on the preparation programs in which they were enrolled. Group One, consisting of 56 participants, was enrolled in the new program in which nine additional hours of mathematics content courses were required beyond the core liberal arts curriculum. Group One had completed at least two of the three additional courses prior to responding to this study. Those courses included Algebra for Teachers, Geometry for Teachers, and Probability and Statistics for Teachers. Group Two, consisting of 57 participants, was enrolled in the traditional preparation program in which no additional content courses were taken beyond those required in the core curriculum.

Data Collection.

A 20-item questionnaire (included in Appendix A) designed by Shaw (1989) was utilized to assess participants' pedagogical and content beliefs about mathematics. The participants responded to each of the 20 items on a 5-point Likert scale indicating whether they "strongly agree," "agree," "not sure," "disagree," or "strongly disagree" with each statement made. A score of one corresponded to "strongly agree" and five to "strongly disagree." The questionnaire was administered to the teacher candidates at the end of their third semester in their teacher preparation program, specifically at the end of their methodology course.

Analysis.

Survey results were analyzed using an independent-samples t-test for equality of means, descriptive statistics, and frequency statistics. An independent-samples t-test was utilized to compare the means of Group One to Group Two. Frequency analyses were conducted within and between the groups to determine percentage variations for each item's response. Descriptive statistics were conducted to determine and compare the range and variance of scores among and between the two groups.

Results

This study examined the impact taking additional mathematics courses had on teacher candidates' beliefs regarding mathematics content and pedagogy. This study found that taking additional mathematics courses produces some significant differences in beliefs. The independent t-test results showed that for three items on the questionnaire, the responses of the teacher candidates enrolled in the new program differed significantly from the responses of the teacher candidates enrolled in the old program. Table 1 presents the means and standard deviations for the items on which the two groups differed significantly.

Table 1
Means and Standard Deviations on Responses Items with $p < .05$

Item	Group	Mean	S. D.
Q1: I can handle basic mathematics, but high school mathematics would difficult for me.	One	3.32	1.16
	Two	2.82	1.35
Q8: Good teachers give their students lots of workbook practice on the skills they have been teaching.	One	3.33	1.07
	Two	3.89	1.01
Q15: If a student asks a question about mathematics, the teacher should know the answer.	One	2.46	.95
	Two	3.14	.97

The t-test results indicated that the teacher candidates who were enrolled in the new program did feel more confident about their ability to handle secondary level mathematics than those teacher candidates who had not had the additional mathematics courses. However, teacher candidates who completed the new preparation program were more in favor of a lot of workbook practice than their counterparts and believed more strongly that the teacher should know the answers to questions students ask. The significance levels for the remaining 17 items ranged from .054 to .963.

Frequency distribution statistics indicated that the manner in which Group One and Group Two responded to each of the items on the questionnaire was very similar. Responses were within 11 cumulative percentage points of each other on 18 of 20 questionnaire items. The items in which significant differences were found did show greater variance. 69.6 percent of Group One “agreed” or “strongly agreed” that if a student asked a question, the mathematics teacher should know the answer. In contrast, only 35.1 percent of Group Two “agreed” or “strongly agreed” with that statement. Additionally, 59.6 percent of Group One “agreed” or “strongly agreed” that teachers should follow the mathematics textbook that their school used while only 17.9 percent of Group Two “agreed” or “strongly agreed” with that statement. Both groups believed that knowing mathematics means being able to make connections in new situations with 87.5 percent of Group One “agreeing” or “strongly agreeing” and 84.2 percent of Group Two “agreeing” or “strongly agreeing”. Both groups also believed that students should never leave mathematics class feeling confused or stuck with 80.4 percent of Group One “agreeing” or “strongly agreeing” and 80.7 percent of Group Two “agreeing” or “strongly agreeing.” At an agreement rate of 85.7 percent and 82.5 percent Groups One and Two, respectively, believed that in order for students to get better at mathematics they need to practice a lot.

Descriptive statistics yielded no notable differences within or between the two groups for any of the items. Participants’ responses were typically within one point of each other on the 5-point Likert scale for both groups. The range of standard deviation scores for Group Two (1.28 - .78) was less than the range of standard deviation scores for Group One (1.35 - .57). For all 20 items on the questionnaire Group One had a least one respondent indicate a “strongly agree” whereas Group Two had two items in which no one indicated a “strongly agree.” None of the teacher candidates in Group Two “strongly agreed" that good teachers give their students lots of workbook practice on the skills they have been teaching nor did any of them "strongly agree" that teachers should follow the mathematics textbook that is used in their school.

The statistical analyses conducted for this study indicated that the participants within each group responded in a similar manner on the questionnaire. Their responses demonstrate homogeneity in beliefs regarding mathematics content and pedagogy within their groups. With the exception of three items, data analyses indicated that homogeneity of beliefs regarding mathematics content and pedagogy between the groups also exists. An independent samples t-test showed that the groups differed significantly only in their confidence in their ability to handle secondary level mathematics, in their beliefs regarding the use of worksheets, and in their beliefs regarding the level of expertise a teacher should have in mathematics. Frequency distribution statistics indicated that while the groups differed greatly in their beliefs regarding the use of textbooks, it was not a significant ($p=.054$) difference.

Summary

Teachers' belief systems are thought to have a significant impact on the mathematics instruction they deliver in their classroom (Ernest, 1989; Carpenter, 1989; and Borko, 1992). A teacher's beliefs about mathematics content in particular are more closely linked to his/her instructional practices (Raymond, 1997). Given the importance of teachers' belief systems, reform efforts hopeful in improving mathematics instruction must seek to impact teachers' beliefs about mathematics content.

This study examined the impact completing three additional mathematics courses in a preparation program had on teacher candidates' beliefs regarding mathematics content and pedagogy. Requiring teachers to take additional mathematics courses is one way policy makers are attempting to improve teachers' mathematics instruction. Overall, however, the findings of this study show that taking additional courses does not significantly impact the beliefs of teacher candidates. Responses to 17 of the 20 questionnaire items yielded no significant differences in beliefs between the two groups studied. Only three items on the questionnaire yielded significant differences between the two groups (see Table 1).

Group One's increased confidence in their ability to handle secondary level mathematics demonstrates the positive effect taking additional courses can have on teacher candidates. Teachers' content background and confidence in their knowledge of mathematics has been shown to impact their instructional practices (Manouchehri & Goodman, 1998). Teachers who have studied more mathematics are more likely to implement practices in line with NCTM standards as well (Thompson, 2001).

Although Group One gained confidence in their own mathematical abilities from taking the additional courses, they also grew more traditional in their pedagogical beliefs. They more strongly believed a lot of workbook practice was good for students and that teachers should know all the answers. Interestingly, these pedagogical beliefs are not viewed as conducive to facilitating mathematics learning in students. In fact, a heavy reliance on textbooks and worksheets is associated more with teachers who are not well prepared in mathematics (Chapin, 1994). The findings indicate that taking additional content courses can affect pedagogical beliefs in a detrimental manner as well.

Explanations for the observed differences in beliefs between groups regarding mathematics pedagogy and content vary. The manner in which the content courses were taught could explain the negative changes. The participants may have experienced traditional teacher-directed instruction in their content courses both contributing to and reinforcing their own traditional beliefs about mathematics instruction. An individual's own experiences as a mathematics student have been found to significantly affect his/her beliefs about mathematics content (Conney, Shealy, and Arvold et al, 1998; Raymond, 1997).

Experimenting with the types of content courses offered to teacher candidates and in-service teachers may also prove to be beneficial in furthering efforts to impact the beliefs and practices of mathematics educators. Several participants in this study shared with the researchers the belief that taking content courses more in line with the specific mathematics content in which they are to instruct would have been more useful to them. While gaining mathematical knowledge, participants reported not being able see how to apply their advanced mathematical knowledge in the elementary classroom. Ensuring that the kind of instruction delivered in mathematics content courses is of high quality is another way teacher preparation programs can avoid possible negative effects from taking additional courses.

Policies are already in place mandating elementary educators take additional content courses. Our goal at this point is to ensure that the courses being offered are generating the types of mathematics teachers intended. To accomplish this, the impact content and pedagogy courses are having on teacher candidates must be continually and thoroughly examined. For future studies, it is recommended that an instrument be developed that examines in more detail beliefs about mathematical content. With a more specific instrument, the factors within one's beliefs about mathematics content that more strongly influence practice can be better determined. Studies which follow this new generation of teachers into their classrooms are also needed. State departments, school systems, and preparation programs are all looking to these programmatic changes to improve mathematics education. Making modifications to required courses based on researched practices is important in accomplishing this goal.

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Appendix A

I.D. Code__________________

For the statements below, indicate your agreement or disagreement by circling the number that best expresses what you think about the statement. Your reply to each statement can range from strongly agree (1) to strongly disagree (5).

1	2	3	4	5
Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree

1.	I can handle basic mathematics, but high school mathematics would be difficult for me.	1	2	3	4	5
2.	There is a point when students should accept mathematical facts whether they understand them or not.	1	2	3	4	5
3.	Knowing mathematics means being able to make connections in the mathematical ideas that arise from different situations.	1	2	3	4	5
4.	Students should never leave mathematics class or end the mathematics period felling confused or stuck.	1	2	3	4	5
5.	If a student communicates the mathematics accurately then the student must understand it.	1	2	3	4	5
6.	For students to get better at mathematics they need to practice it a lot.	1	2	3	4	5
7.	Having students understand the basic computational skills is very important in elementary school mathematics.	1	2	3	4	5
8.	Good teachers give their students a lot of workbook practice on the skills they have been teaching.	1	2	3	4	5
9.	If a student is confused in mathematics, the teacher should go over the material beginning with what the student already understands.	1	2	3	4	5

I.D. Code__________________

1	2	3	4	5
Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree

10. A teacher should wait until students are developmentally ready before introducing new ideas and skills. 1 2 3 4 5

11. Teachers should avoid grouping students by ability or level of performance. 1 2 3 4 5

12. Teachers should teach for relational understanding only after students have attained the necessary skills. 1 2 3 4 5

13. Taking additional courses I mathematics would help me teach mathematics better. 1 2 3 4 5

14. Keeping students quiet during mathematics class helps them learn better. 1 2 3 4 5

15. If a student asks a question about mathematics, the teacher should know the answer. 1 2 3 4 5

16. Getting more experience teaching mathematics would help me teach mathematics better. 1 2 3 4 5

17. Teachers should follow the mathematics textbook that is used in their school. 1 2 3 4 5

18. Standardized tests are pressuring teachers to teach differently. 1 2 3 4 5

19. I am sure teaching will be my life-long career. 1 2 3 4 5

20. I am currently rethinking many of my ideas about teaching mathematics. 1 2 3 4 5