

**The Effects of a Math Curriculum Course on the
Beliefs of Pre-service Teachers Regarding the
National Council of Teachers of Mathematics' Standards**

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Abstract

The present study examined the extent to which a secondary curriculum course on the NCTM Standards effects the mathematics teaching beliefs of pre-service teachers. The sample consisted of 25 pre-service secondary mathematics teachers enrolled in a major research university in the South. The Standards Beliefs Instrument (SBI) was used on a pretest and posttest basis during a fifteen week course to measure pre-service teachers' beliefs on teaching mathematics in accordance with NCTM Standards (1989). The results indicate a significant difference ($p < .05$) in the pre-service teachers' beliefs in agreeing with the NCTM Standards. Implications for research, theory, and practice are also examined.

Introduction

A changing, economically competitive world, predicated a need for reform in mathematics education. Research conducted by the Board of Directors of the National Council of Teachers of Mathematics (NCTM) in the mid 1980's indicated that the mathematics curricula for elementary and secondary schools in the United States was not sufficient. The NCTM Standards came about as an extension of Americans' responses to the demand for change. Hence, NCTM felt there was a need for standards to improve nationwide test scores in the area of mathematics. In 1989 the National Council of Teachers of Mathematics published, *Curriculum and Evaluation Standards for School Mathematics*. The NCTM Standards was established as a broad framework to guide reform in school mathematics (NCTM, 1989). Burns (1998) contends that two-thirds of Americans loathe or hate mathematics. The TIMSS study had shown that American students as they continue on in age from grades four to grade twelve are doing poorer in mathematics as compared to other students around the world (Schmidt, 1998). It is thus important that math teachers are well prepared in teaching mathematics in order that students are better prepared for the new millennium full of technology as well as to develop positive dispositions toward mathematics. The NCTM's vision includes mathematics teachers encouraging students, probing for ideas, and carefully judging the maturity of a student's thoughts and expressions (NCTM, 1989). The need for implementation of the standards is essential, since current teaching practices in mathematics classrooms often does not provide sufficient critical

thought. Since teachers tend to teach the way they were taught, Sarason (1993) believes that any reform in education must first begin with teacher training. Practicing mathematics teachers and pre-service teachers, thus, need to be trained to implement these standards. Furthermore, if schools are going to improve the quality of teaching mathematics, then the teachers themselves are going to need to believe in these Standards.

The purpose of this study was to determine whether there will be a significant difference between pretest and posttest scores on the Standards' Belief Instrument (SBI) for pre-service mathematics teachers enrolled in a secondary mathematics curriculum course (MA 306) at a university in the southeast.

Recent research in mathematics education (Bush, Lamb, & Alsina, 1990; Fullan, 1983; Kessler, 1985; McGalliard, 1983; Silver, 1985; Thompson, 1984) indicates teaching behavior is profoundly or subtly affected by teacher beliefs concerning mathematics. Thompson (1984) found that mathematics teachers' opinions, beliefs, and inclinations swayed their instructional practices. Thus, many inappropriate teaching methods could be attributed to teachers' tenets about teaching (Ferrini-Mundy, 1986). The results of the present study can be used to help provide evidence regarding the potential for changing these beliefs.

Operational Definition

For the purpose of this study, a belief was defined as, "a judgement of the credibility of a conceptualization. Credibility of a conceptualization has to do with whether one accepts, rejects, or suspends judgement concerning a set of concepts and the interrelationships among these concepts" (Reyes, 1987, p.10). The creators of the SBI used this same definition.

Limitations

The following are considered to be limitations to the study: (a) This study is limited to pre-service mathematics education majors taking a pretest and posttest of the SBI at a university in the southeast, thus may not be generalizable to other settings, (b) The relatively small sample size could limit the quantitative aspects of this study, and (c) The role of the instructor of the secondary mathematics curriculum course might encourage normative responses on the part of some participants, which could limit the validity of the study, and (d) the SBI may not be sensitive enough to adequately reflect change in the beliefs of pre-service teachers.

Literature Review

Research on mathematics teachers' beliefs on the use and need for the NCTM standards was introduced by Zollman and Mason in 1992 after they designed and tested an instrument that they named the Standards Beliefs Instrument (SBI) (Zollman & Mason, 1992). Zollman and Mason developed the SBI in order to test mathematics teachers' attitudes towards teaching according to the 1989 NCTM's Standards. The goal of the SBI was to develop an instrument that could be used to access the beliefs of teachers about the NCTM Standards. Zollman and Mason (1992) suggest that their instrument is useful in this regard. The SBI was specifically developed to measure mathematics teachers' beliefs regarding to the NCTM Standards. The SBI provides a myriad of implications for teaching mathematics. In order to provide a basis for understanding the implications for teaching the NCTM Standards, research related to mathematics teacher preparation, teacher beliefs, attitudes towards mathematics education, and the implementation of the NCTM Standards have been included. Finally, Zollman and Mason (1992) contend that an important relationship exists between the teacher's beliefs and the teacher's own style of teaching. Therefore, a wide acceptance of the NCTM Standards could hinge on a teacher's

beliefs.

Researchers continue to emphasize the need to reform teacher education to promote a corresponding transformation in mathematics instruction in today's schools. Sarason (1993) believes that if one wants to change the education of students, one needs to first change the education of teachers. Hence, it is necessary to prepare educators for what life is like in classrooms, school, school systems, and society. Sarason believes that in the case of reform, educators need to first focus on preparing teachers differently. The NCTM Standards can act as a genesis for this preparation (NCTM, 1989). The pre-service and continuing education of teachers of mathematics should provide them with opportunities to examine and revise their assumptions about how mathematics should be taught, and how students learn mathematics (NCTM, 1989, 160). Thus, pre-service mathematics teachers need to prepare for teaching towards the year 2000.

Gadanidis (1994) claims that teachers must have an understanding of the NCTM theory before they are able to put theory into practice. This idea reflects the NCTM's *Professional Standards for Teaching Mathematics* (1991), where it is stated, "the final success for any teacher is the integration of theory and practice."

O'Laughlin (1990) found that beginning teachers maintain definite beliefs in regards to knowing, learning, and teaching, which usually lead them to endorse didactic approaches with the teacher acting as the primary conveyer of knowledge. A teachers' beliefs about students' abilities greatly influence the decisions the teacher makes about the learning environment (Lubinski, 1994). Lubinski (1994) feels that teachers who believe that the content of the mathematics in their classroom is guided by the textbook make different decisions than do teachers who believe that students' interests and ability guide the content of the mathematics. Research indicates that teachers' beliefs and teachers' knowledge is related to the instructional decision-making process (Fennema & Franke, 1992; Parares, 1992; Thompson, 1992). Therefore, what a teacher believes about teaching and learning mathematics and what a teacher knows about the content, methods, and materials available to teach mathematics, influence the teachers' instructional decisions.

Research related to the issue of attitudes towards mathematics education is extensive. In addition, the NCTM Standards recognize that mathematics has become extremely important in today's world. One of the most important factors in developing students' mathematics ability is the attitude of their teacher in the discipline (Meyer, 1980).

The knowledge of the students' thinking is very important; teachers' knowledge of mathematics content and pedagogy is also critical to the culture of the learning environment. Knowledge of the content and pedagogy in conjunction with students thinking allows a teacher to design blueprints for worthwhile mathematics tasks (Lubinski, 1994).

Research has shown that it is critical for secondary mathematics teachers to have strong mathematical knowledge, a positive attitude toward mathematics and teaching, as well as an alignment with proper pedagogical beliefs (Kerr & Lester, 1982; Meyer, 1980). It is believed that mathematics education majors have not been exposed to enough alternative teaching methods to be capable of teaching mathematics with an emphasis on meaning (Ball & Wilson, 1990). Ball (1990) discovered that pre-service secondary mathematics teachers often lack sufficient mathematical understanding to teach the subject effectively. Farrell and House (1994) believe that prospective mathematics teachers must construct knowledge about teaching, and in the process they frequently must reconstruct their knowledge of mathematics. In 1991 the National Council of Teachers of Mathematics along with the Association for Supervision and Curriculum Development published, *A Guide for Reviewing School*

Mathematics Programs, in this document they claimed that in order to have high-quality mathematics programs, teachers of mathematics must be well prepared, process and demonstrate positive attitudes, continue to grow professionally, and be actively involved in educational issues that affect the quality of their students' learning (NCTM & ASCD, 1991).

The research that exists on the implementation of the NCTM Standards is immense since its publication in 1989. The NCTM Standards presents a picture of a classroom instruction that differs from present practice in secondary schools. The implementation of the Standards involves a restructuring of mathematics instruction, which involves the implementation of the NCTM Standards, for both pre-service and in-service mathematics teachers (Parker, 1991). One professor of secondary mathematics education found that she needed to change her teaching pedagogy in order to incorporate NCTM Standards. She found that even well prepared mathematics students experienced a great deal of trauma as a result of learning mathematics in new ways. The professor modeled the NCTM Standards in her teaching. The activities included: cooperative problem solving with manipulatives such as: geoboards, tangrams, algebra tiles, technology, etc. (Farrell & House, 1994). Farrell and House (1994) contended that by teaching mathematics methods students by incorporating the NCTM Standards helped the students learn mathematics in a new way, thus acting as models for the future mathematics educators to teach in a similar fashion. Hence, for pre-service mathematics teachers to incorporate the Standards, they must learn mathematics in a new manner in which they construct this new knowledge, and are able to teach it in this way also. The Standards document recommended a departure from conventional forms of instruction and evaluation, and recommended a more holistic approach to conveying the content knowledge. Other researchers believe that there must be a link between pedagogy and mathematics, and that during pre-service teacher training, the students must have a hands-on approach in their math methods course in order to fully implement the Standards (Cooney & Friel, 1992). Edgerton (1992) contends that after observing in-service teachers implement the NCTM Standards, the task of achieving this effort is going to be grand. The implementation of the Standards demands a great deal of teacher training to fully incorporate the Standards in mathematics classrooms, for now, the standards are slowly being fulfilled in a fragmented manner.

The review of literature has provided information concerning the attitudes, content knowledge, pedagogy, beliefs, and preparation of pre-service teachers regarding the implementation of the NCTM Standards. The research indicates that there exists a great body of knowledge in regards to how a teachers beliefs, knowledge, and pedagogy affect the way in which one would actually teach. The NCTM Standards address the issues facing today's young people, and provide a way to make mathematics more meaningful. They contend that the teacher must consider these issues. The new generation of teachers can act as the Greek God of sending messages, Hermes, on what research has shown to be a better approach to teaching mathematics. The present study attempted to add to this body of knowledge by investigating the effect of a mathematics curriculum course on the pedagogical beliefs, mathematical knowledge, mathematics teacher preparation, and implementation of the NCTM Standards of pre-service secondary mathematics teachers.

Methodology

The purpose of this study was to determine if a curriculum course could significantly effect the attitudes of pre-service teachers' beliefs regarding NCTM's Standards. This question will be answered by comparing their pretest and posttest scores on the SBI. This study is intended to help math education educators, as well as anyone in the discipline to become aware of how a mathematics

curriculum course on the NCTM standards can impact future teachers' beliefs in teaching mathematics. The results of the study will give mathematics education faculty insight into what needs to be emphasized during their instruction.

Subjects

The subjects included twenty-five pre-service teachers enrolled in Curriculum in Secondary Mathematics Education at a university in the southeast. The university used in the study is a major public research university with an enrollment of approximately 20,000 students. The university is in Tuscaloosa, Alabama, which is located in West Alabama. The community has a population of approximately 100,000 inhabitants. The class included seven males and eighteen females. The subjects ranged in age from 20 to 34, with the median age being 22 years old. All subjects in the study were either ranked as juniors or senior at the university. Four of the twenty-five students had taken a previous course with the same professor called Mathematics Methods in Secondary Education. All of the subjects have previously taken mathematics courses above calculus level mathematics, as well as several education courses (Intro. to Ed., Mainstreaming and Ed. Foundations). The subjects were unaware of the reasons for the study until all data was collected, they were then debriefed.

Instrument

The Standard's Belief Instrument (SBI) (Zollman & Mason, 1992) was used to assess the pre-service mathematics teachers' beliefs towards the NCTM Standards on a pretest/posttest basis. The SBI consists of sixteen questions based on the NCTM Standards from the NCTM's publication *Curriculum and Evaluation Standards for School Mathematics*. A pretest and posttest measure from the SBI was examined.

The Standards' Belief Instrument (SBI) was specifically developed by Zollman and Mason to measure teachers' beliefs about the NCTM "Curriculum and Evaluation Standards" using items representative of beliefs about the Standards. The SBI consists of sixteen questions regarding the Standards. Scores on this instrument will range from 0-16 based on the agreement of subject response and the NCTM Standards. Items for the SBI were chosen from several levels of the Standards in attempt to be representative of them. The sixteen items of the SBI were either nearly direct quotes from the Standards or an inverse of a direct quote from the Standards. Zollman and Mason provide a guide in their article, *The Standards' Belief Instrument (SBI): Teachers' Beliefs about the NCTM Standards*, citing the pages in the "Standards Document" from which each question was formulated. The subjects, upon completing the posttest, were asked to complete a demographic/prior knowledge questionnaire. This demographic questionnaire included information about sex, age, class rank, and four questions regarding the previous knowledge of the Standards that the student may have had. The information from this questionnaire was used to aid in providing a qualitative component to this study. Taken together the qualitative and the quantitative data provide a better-rounded depiction of the effects of a secondary mathematics curriculum course.

Implementation

The Standards' Belief Instrument was administered on a pretest-posttest basis to the twenty-five MA 306 students. A pretest was administered the first day of classes before any instruction on the Standards took place and a posttest was administered during the last week of classes. The administrations of the SBI took place during class. Respondents were given as much time as needed to complete the SBI. The students were given a separate demographic survey to fill out after the revised

SBI. The scoring of the pretests and posttests from the subjects were done by hand. The subjects demographic and their two scores were analyzed. Along with the demographic information, the subjects were also asked some subjective types of questions related to the Standards. The questions included are: (a) Have you heard of the NCTM Standards prior to this course? If so, in what context?; (b) What, if any, other mathematics education courses have taught you about the NCTM Standards?; (c) How do you feel this course has influenced you as a mathematics teacher when you have your own classroom?; and (d) Include comments on the NCTM Standards, i.e. use of: 1. Cooperative Learning, 2. Manipulatives, 3. Technological Aids; 4. Problem Solving, and 5. Other:_____.

Curriculum Course Description (Treatment)

The MA 306 curriculum course met twice a week, for one-hour and fifteen-minutes for fifteen weeks. The following include the instructors goals and objectives for the course: (a) to understand the causes of the present condition of mathematics education as identified by the NCTM in *Curriculum and Evaluation Standards for School Mathematics*; (b) to understand the underpinnings of current efforts to reform mathematics education; (c) to understand and analyze the mathematics curriculum of the state of Alabama; (d) to describe the different types of learning experiences that must occur to promote the development of mathematical learning in students k-12; (e) to identify and present instructional strategies appropriate for secondary mathematics; (f) to understand the role of problem solving, manipulatives, technology, and, cooperative learning in the teaching of mathematics; (g) to plan lessons using teaching strategies consistent with the recommendations of NCTM's *Standards*; (h) to communicate mathematics effectively, both in writing and orally; (i) to understand a variety of means by which mathematical understanding can be assessed; (j) to evaluate/reflect on the effectiveness of curriculum and instruction in the mathematics classroom; (k) to understand the teacher's role in the mathematics classroom, including responsibility to the diversity of students and their various learning styles; (l) and to develop an appreciation for the field of mathematics education, and to professional responsibilities of the secondary school mathematics teacher. The structure of the class consisted of active engagement on the part of the students, who, on a daily basis participated in a variety of activities, which modeled NCTM's Standards. The students also took part in meaningful discussions about reactions to the various activities. Assignments included: lesson planning, reflective writing, and a class presentation. The course overall was an extremely active, hands-on approach to teaching a secondary mathematics curriculum course. The following is the description based on the undergraduate catalog:

Mathematics 306. Curriculum in Secondary Mathematics: Three credit hours.

Prerequisites: Admission to the Teacher Education Program in secondary mathematics, BCT 300 (Intro. to Computers), and MA 227 (Calculus); or permission of the instructor. Future secondary mathematics teachers examine advanced concepts, structures, and procedures that comprise secondary mathematics.

Results

The purpose of this study was to consider the effects of a secondary mathematics curriculum course on the beliefs of the NCTM Standards of pre-service secondary mathematics teachers. In this section the results of the statistical tests performed on the quantitative hypothesis is discussed. The use of some qualitative investigating will also be considered, in order to give a better-rounded depiction of the effects of a secondary mathematics curriculum course.

Research Hypothesis

Hypothesis: It is hypothesized that there will be a significant difference between the scores on the SBI posttest compared to the pretest for the MA 306 Students after a fifteen week course entitled curriculum in Secondary Mathematics.

A paired t-test was performed comparing the pretest (mean = 10.56) and posttest (mean = 12.24) scores on the SBI of the pre-service secondary mathematics teachers. Three subjects were eliminated from the analysis due to invalid pretest scores or because of mortality rate. The difference in means was found to be statistically significant, $t(24) = 4.30$, $p < .0002$. Table 1 shows the percentage of respondents who agreed with the NCTM Standard based on the SBI.

Table 1
Percent of Respondents In Agreement with the NCTM Standards on the Revised Standards Beliefs

Question #	Instrument (SBI) (by Question)	
	Subjects (N = 25)	
	Pretest	Posttest
1	84.0	92.0
2	100	100
3	96.0	100
4	100	100
5	100	100
6	100	100
7	84.0	96.0
8	44.0	40.0
9	16.0	16.0
10	28.0	56.0
11	40.0	60.0
12	16.0	8.0
13	80.0	96.0
14	20.0	68.0
15	96.0	100
16	52.0	92.0

As part of this study, the subjects were also asked to respond to a number of subjective questions related to the course and the NCTM Standards. From the twenty-five subjects, roughly two-third had been exposed to the NCTM Standards in other courses they had taken. The following are some responses from the subjects regarding how the curriculum course in secondary mathematics has influenced them: "It has made me more prepared and has given me many ideas."; "It has changed my image of the way I will teach."; "The course has caused me to be more creative in lesson development."; "I know about the manipulatives available to my students and how to use them to teach math effectively."; and lastly, "[The course] greatly influenced me; It has shown me fun, creative ways to teach math." All subjects responded positively and expressed the importance of the use of: cooperative learning, math manipulatives, technological aids, and problems solving, in a mathematics classroom.

Implications

The objective of this study was to determine if a curriculum course could significantly effect the attitudes of pre-service teachers' beliefs regarding the NCTM's Standards. The results of this study indicate that a curriculum course can have a significant impact on pre-service teachers regarding their beliefs concerning the NCTM Standards. The genesis of successfully incorporating the NCTM Standards may depend then on the type of pre-service teacher training that is provided. From the item analysis (Table 1) there are a great number of implications that can be inferred, items 9 and 12 are just two of the four questions that focus on the NCTM Standards K-4, the low scores on these items may imply that secondary mathematics students need to have more of a holistic understanding of pre-secondary mathematics. It could be inferred that secondary methods courses need to focus on how a student learns mathematics, therefore, the teacher would have a better understanding of the mathematical stage. This study suggests a significant increase in agreement between pre-service teacher beliefs on teaching mathematics and the NCTM Standards.

It is suggested that further studies be conducted on in-service mathematics teachers to see if there would be a significant increase in teacher attitudes towards the NCTM Standards for this population after training on the NCTM Standards. Unfortunately, it is possible that a great number of practicing in-service secondary mathematics teachers are currently unaware of the NCTM's 1989 Standards. The SBI may be used as an instrument to help in providing information to schools and teachers as to the need in teacher training on the NCTM Standards. Overall, the data from Table 1 shows that pre-service teachers' beliefs can be changed if presented with the proper knowledge and adequate training. Therefore a pre-service curriculum in secondary school mathematics course that imparts and models the beliefs of the NCTM Standards can be valuable in effectively transmitting the objective of the National Council of Teachers of Mathematics. Researchers need to further examine factors such as pedagogical beliefs, content knowledge, and teacher preparation of both pre-service and in-service teachers in order to fully implement the NCTM Standards in a more widespread manner. Such efforts should be beneficial to all of our students and have a positive impact on the economic and social future of the United States.

Conclusion

The results of this study suggest that pre-service mathematics teachers are receptive to the mathematical pedagogy recommended by the National Council of Teachers of Mathematics. The importance of modeling and teaching about the NCTM Standards is crucial in all mathematics methods courses. With the advent of the new NCTM Standards that will be published in the Spring of 2000 (NCTM, 2000) math educators need to take a look at how what is done in a math methods class can impact preservice teachers beliefs about what is done in the classroom with our K-12 students. The results from this study may provide hope and encouragement for educators of mathematics methods courses as they confront the challenge of preparing pre-service teachers to amend mathematics education in the next millennium.

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