

## **Exploring Beliefs and Practices of Secondary Mathematics Teachers Who Participated in a *Standards*-Based Pre-Service Education Program**

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### Abstract

The National Council of Teachers of Mathematics has challenged all mathematics teachers to use the *Standards* documents (1989, 1991, 1995, & 2000) as guidelines for teaching mathematics. Many pre-service programs are now presenting curricula that are *Standards*-based. Five case studies were used to investigate the teaching beliefs and practices of mathematics teachers who had participated in a *Standards*-based pre-service education.

One teacher held beliefs in alignment with the guidelines of the *Standards* and effectively implemented them in her classroom regardless of the obstacles. Another teacher strongly held *Standards*-based beliefs but had difficulty incorporating these beliefs into her teaching practices due to the obstacles of curriculum, high-stakes testing, and classroom management. The other three teachers held mostly traditional beliefs and incorporated traditional teaching strategies. Four of the teachers lowered their expectations of students based on the students' demographics, such as academic level and socioeconomic status.

The National Council of Teachers of Mathematics (NCTM) has challenged all mathematics teachers to use the *Standards* documents (1989, 1991, 1995, & 2000) as guidelines for teaching mathematics. Most pre-service teachers experience a traditional high school education, and some of them participate in a pre-service education that emphasizes the guidelines of the *Standards*. The resulting conflict forces mathematics teachers to assess their own beliefs and practices. What effect do the methods courses, field experiences, and internships have on these pre-service teachers' beliefs and practices? An effective pre-service secondary education may produce some mathematics teachers whose beliefs are in alignment with the *Standards*, but some teachers may continue to hold traditional beliefs about teaching mathematics (Van Zoest & Bohl, 2002). Which teaching beliefs and practices will teachers

choose as they transition to the classroom? Pre-service teachers may begin their careers in a variety of school climates that run the gamut from traditional to *Standards*-based. Influences in the school climate can significantly impact teachers' practices (LaBerge & Sons, 1999).

### Theoretical Basis for the Study

In order to determine how a mathematics teacher's beliefs system is affected as they enter the classroom, a theoretical basis must be established that defines beliefs and beliefs systems. Leatham (2006) proposed the *sensible system* framework for systems of beliefs which presumes that teachers' beliefs influence their actions and practices. Additionally, individuals are not necessarily aware they are holding certain beliefs, so a researcher cannot simply arrive at teachers' beliefs by asking them about their beliefs but must make inferences from a variety of sources (Leatham, 2006). Teachers' beliefs about various facets of teaching cannot be viewed in isolation but the connection of different beliefs must be articulated. The sensible system framework assumes that individuals organize beliefs into systems that are logical to them. For a sensible system of beliefs to exist, an individual's beliefs must make sense with respect to his or her other beliefs (Leatham, 2006). The strength of certain beliefs is dependent upon how strongly they fit in with the rest of the belief system. If a teacher's beliefs that are seemingly contradictory collide, then the teacher must resolve the conflict in order to make the system sensible (Leatham, 2006).

In this study, the major tenets of the sensible systems of beliefs framework were used to examine teachers' beliefs and practices. This framework was used because the existence of a sensible belief system of each participant aided in explaining the connection between teachers' beliefs and practices. A case study approach helped to provide an in-depth and detailed image of teachers' beliefs and practices using a variety of data sources. When contradictions appeared to exist in the belief system, a closer examination was made to attempt to rectify the discrepancies.

### Purpose

The purpose of this study was to contribute to an understanding of the relationship between the beliefs and the practices of secondary mathematics teachers who participated in a *Standards*-based pre-service education. The relationship was viewed using a lens based on the *Standards* guidelines about mathematics teaching and learning. This study was guided by the following research questions:

1. To what extent are secondary mathematics teachers incorporating the *Standards*-based approach that was promoted in their pre-service education?
2. How consistent are the secondary teachers' beliefs with a *Standards*-based teaching framework?
3. To what extent are other factors impacting secondary mathematics teachers' beliefs and practices toward *Standards*-based mathematics?

4. To what extent do teachers change their teaching style based on student demographics, such as socioeconomic status, race, gender, and ability level?

### Context of the Study

Before turning to the specifics of the methodology of this study, I will provide a context for the discussion of the participant selection process. In this study, all of the mathematics teachers experienced a traditional high school education while they all participated in a pre-service education at Southern State University, a public university in a southern state that stressed the guidelines of the *Standards* (NCTM, 1989, 1991, 1995, & 2000). Some of the case study subjects were involved in the Communicating Through Mathematics (CTM) systemic project. CTM promoted teaching strategies based on the guidelines of the *Standards*. CTM provided a summer institute, quarterly meetings, and localized workshops for school systems in fifteen counties. Some teachers were additionally involved as school teacher leaders, district teacher leaders, or presenters for the institute and workshops. This study examined what happened to the secondary mathematics teachers' beliefs and practices during the first few years of teaching.

### Methodology

A case study approach was chosen as the methodology to investigate teachers' beliefs and practices in order to obtain a "rich, 'thick' description of the phenomenon under study" (Merriam, 1998, p. 29). Data sources included in this study consisted of multiple sources: the Teacher's Practices and Beliefs Survey (TPBS); classroom observation transcripts; Reformed Teaching Observation Protocol (RTOP) instrument (AzTEC, 2002); two observation periods of five consecutive days; observation notes taken during each observation period; and pre-observation and post-observation interviews.

The TPBS was adapted from the beliefs and attitudes survey developed by the Evaluation Planning Team of CTM and was sent to all mathematics education graduates from Southern State University from 2001 to 2007. The responses to the TPBS in the areas of teachers' beliefs, teachers' practices, and teachers' beliefs and practices toward equitable teaching were used to narrow the field of possible case study participants. I looked for a sample that varied under the following factors: years of teaching, level of education (bachelor's degree vs. master's degree), perceived ability level of classes, teaching at schools that participated in the CTM systemic project, geographic location of the school where they were teaching, and diversity of classes taught. Five teachers agreed to participate as case study participants.

To initiate the data collection process, I asked each case study participant a predetermined list of questions in the first interview prior to any observations. Further explanation on questions was explored if the participant's answer called for clarification. The

participants were also asked to respond to specific teaching events that took place during the follow-up observations. The questions in the closing interview also investigated the teachers' beliefs and practices as they pertained to specific events witnessed during the second observation period. The RTOP (AzTEC, 2002) was used to guide classroom observations. The RTOP was developed to provide a reliable method for determining the degree to which reform methods were being implemented by mathematics and science teachers. I took field notes during each observation to get a better picture of each classroom environment. These notes included incidents of students getting out of their seats, passing notes, not on task, texting, listening to music, and communicating across the room to their friends, and any information that could not be heard on the tape.

The data gathered from observations notes, interviews, and transcripts of classroom observations represented a major portion of the data for this study. The coding of this data was based on a grounded theory approach as defined by the guidelines of Strauss and Corbin (1998). I located themes and assigned initial codes or labels in a first attempt to condense the mass of data into categories. After reading each of the documents, response patterns surfaced and similarities were noted. The four general categories that emerged as the main themes throughout the data were teachers' beliefs, teachers' practices, questioning techniques, and factors that teachers' teaching practices. These categories held strong connections to the research questions for several reasons—the interviews were developed from the research questions, the observation transcriptions described teacher practices, and the notes taken during observations were taken with the research questions in mind. After analyzing each of the single cases, a cross-case analysis was conducted in order to compare and contrast the practices, influences, and characteristics of the various cases (Merriam, 1998).

## Results

In the next section, the results of the research will be described. Each of the five teachers will be briefly described followed by the findings from the observations, interviews, and other data collection.

### *Case 1: Mr. Easterly*

Mr. Easterly had been teaching five years and was in his second year at Rolling Hill High School. Rolling Hill High School was not located in a county that participated in the CTM systemic project. The school was three quarters White, but Mr. Easterly's classes were not representative of the demographics of Rolling Hill High School. Mr. Easterly taught four sections of Algebra IA and one section of Algebra III. Mr. Easterly had access to all of the latest technologies—a tablet computer that was used in connection with an LCD projector, a computer at his desk, and a document camera. The strict order of Mr. Easterly's teaching was also apparent in his classroom.

Mr. Easterly believed that the direct method of teaching was the best method. He had two reasons for his beliefs. First of all, he had a positive experience in his pre-college education with direct teaching and wanted to teach in a similar fashion. Secondly, his internship reinforced these beliefs; his cooperating teacher taught in a very traditional manner. He saw his role as a teacher to be twofold. One was to teach mathematical concepts, and the second was to instill a good work ethic in his students. The data collected on Mr. Easterly points to a traditional teaching style. He rejected the *Standards*-based practices presented in his methods class, and his traditional internship experience solidified his traditional beliefs and practices. Mr. Easterly's traditional beliefs were in alignment with his teaching practices. The administration was the only factor that had a considerable impact on Mr. Easterly's teaching practices. His administration was extremely supportive of a traditional teaching style and discouraged unruly group activities. The majority of his fellow teachers also incorporated traditional methods of teaching. Mr. Easterly had definite beliefs that classes that are perceived as lower ability required different teaching strategies. Mr. Easterly omitted conceptual explanations of certain topics for slower-paced classes.

#### *Case 2: Ms. Danforth*

Forrest Park High School was the location of Ms. Danforth's second year of teaching. The student population of the school was all African American with 86% of the students qualifying for free or reduced lunches. Ms. Danforth taught six sections of algebraic connections, a senior-level class for students who took a low-level class for the fourth required mathematics curriculum. Ms. Danforth was born and raised in the Middle East. Her husband was a professor, and she had two grown children. Ms. Danforth felt that her motherly experience helped her to deal with her senior students whose lives were at a crossroads. Before coming to the United States, Ms. Danforth taught mathematics 11 years in her homeland. Since she was not certified in the United States, she opted for an alternative masters in mathematics education. The administration gave Ms. Danforth free reign to teach her classes. Forrest Park High School was marginally involved in the CTM systemic project, but Ms. Danforth had not attended the summer institute. However, she worked as a presenter for CTM during her tenure as a graduate assistant at Southern State University.

Ms. Danforth entered her pre-service education from a very traditional background. Her teaching practices reverted back to traditional strategies even though she learned how to organize *Standards*-based group activities during her internship with a cooperating teacher who practiced effective *Standards*-based strategies. There was very little collaboration among the faculty at Forrest Park, but most of the teachers implemented traditional methodologies independently of each other. After Ms. Danforth began teaching at Forrest Park, she adjusted her beliefs in particular to older high school students. She supported the *Standards*-based teaching practices for younger students at the elementary and middle school levels but felt differently about juniors and seniors. Since Ms. Danforth only taught seniors in high school,

she had modified her beliefs for this specific grade so that her beliefs were in alignment with her traditional teaching practices.

A number of factors definitely seemed to solidify Ms. Danforth's traditional beliefs and teaching practices. In order for group rules to be effective, the classroom discipline must be under control. Both the chaotic nature of the school and Ms. Danforth's poor classroom management hampered the implementation of *Standards*-based activities. Tardiness in connection with the time element in a 50-minute lesson added to the difficulties of implementing *Standards*-based practices. Examining other factors, Ms. Danforth altered her teaching style based on her students. She expressed concern about her students' socioeconomic status, background, and home life. In the case of Ms. Danforth, her caring attitude actually created a negative impact for her students because she lowered her expectations due to their home life and socioeconomic status and reduced her assignments based on these expectations. Her concern about providing guidance in her students' lives seemed as important in her teaching role as teaching mathematics skills.

### *Case 3: Mr. Barry*

Mr. Barry is a White male teacher who was in his inaugural year as a mathematics teacher. He taught in the Riverwood School System which has earned a reputation for excellence in education over the years. Riverwood School System was not located in the same geographical region as the CTM systemic project and was not involved in the project. Returning home to the school of his youth, Mr. Barry jumped at the opportunity to teach at his former alma mater. Mr. Barry taught all of the eighth-grade students, and his classes consisted of two pre-algebra classes and one algebra seminar. The algebra seminar was designed for the "advanced" students in the eighth grade. In keeping with the orderliness of Riverwood, Mr. Barry's room was tidy and conveyed a feeling of organization even though he taught in a portable classroom. The students were seated in very straight rows. His room was equipped with technological "niceties" including a document camera and a classroom computer that were connected with an LCD projector. Riverwood administration promoted a traditional curriculum and the use of pencil-and-paper calculations instead of the use of calculators. In addition, regular preparation for standardized tests was also encouraged.

Mr. Barry's teaching practices represented a modified traditional approach. The general format of his teaching followed a very traditional pattern. However, he integrated *Standards*-based strategies in a variety of ways. Mr. Barry encouraged student participation and student-led discussions, but they were mostly in whole-group situations. He attempted to introduce new mathematics topics conceptually but did not include the students' investigative phase of the concepts. Mr. Barry was cognizant of his questioning and wanted to use high-order questioning as much as possible. Mr. Barry did not have a problem with the procedural-based curriculum, and he also felt that doing calculations by pencil and paper was better than using calculators. Mr. Barry had adapted both his beliefs and teaching practices so that they were in alignment. He adjusted his beliefs so that they were a mix of traditional and

*Standards*-based. His teaching practices followed his new compromise of his beliefs. Mr. Barry felt that his own high school mathematics teachers had used traditional teaching practices that were effective but lacked the conceptual basis. He integrated the conceptual basis, engaging problems, and student involvement of presentations with the traditional teaching strategies.

Mr. Barry's beliefs and teaching practices were influenced by several factors. The curriculum was geared for a very traditional teaching style, and the administration was convinced of its effectiveness. Mr. Barry felt that the fact that he was not tenured gave him virtually no options for different strategies. Because of the strong pressure felt from the administration, Mr. Barry worked independently and was not impacted by his fellow teachers. The looming threat of standardized test scores was an additional incentive for Mr. Barry to stay on track and not take time for student explorations. The administration felt that covering the curriculum was imperative for achieving excellent test results. Finally, the expectation for an orderly class was a deterrent for group activities and other *Standards*-based strategies. The perceived ability level of Mr. Barry's classes was an additional factor that affected Mr. Barry's beliefs and teaching practices. He readily admitted his affection for his algebra seminar class and expressed doubts about the abilities of his pre-algebra class.

#### *Case 4: Ms. Anthony*

Ms. Anthony was in her second year at Northern Junior High School, a rural community school. She had three prior years of experience at another school. The ratio of Whites to African Americans was approximately two to one and about half of the students were eligible for free or reduced lunch. Ms. Anthony taught two seventh-grade classes and two eighth-grade classes. She taught one advanced and one non-advanced class for each grade. Ms. Anthony was also very involved with the drama productions at the school. Ms. Anthony had initially earned a bachelor's degree in science and later decided to return for an alternative master's degree in mathematics education. Ms. Anthony was a young White female bubbling with enthusiasm. Ms. Anthony was a school teacher leader for the CTM systemic project connected with Southern State University.

Both of the classes I observed during Ms. Anthony's lessons were made up of seventh-grade students. One class was a basic mathematics class for students who were perceived as low-achieving, and the other class was a faster-paced pre-algebra class. The school system used a traditional textbook, but Ms. Anthony supplemented it with student-centered activities. The administration expected the teachers to follow a 7-month curriculum policy. This policy required the teachers to cover the entire curriculum in seven months and give benchmarks each month to test the objectives for that month. Ms. Anthony had virtually no technology available to her with the exception of a classroom computer. She often gave students transparencies to present their solutions on the overhead projector.

Ms. Anthony's displayed tendencies of disorganization in her classroom, teaching, and discipline style. Ms. Anthony's eclectic interests and the students' use of the room for storage

of athletic and academic equipment added to the cluttered nature of an already crowded room. Ms. Anthony admitted that she needed to work on developing stronger routines and sticking with them. Her lack of discipline was a hindrance to working in groups and using activities as a regular teaching strategy. Ms. Anthony revealed that she started out with formal groups with rotating roles but did not continue to follow through with the routines as the year progressed. She described her role in teaching as that of a “guide” and consciously made an effort to “make her students think, not just feeding it to them.”

Ms. Anthony’s basic mathematics class was not representative of the makeup of Northern Junior High School. In a class of 26 students, 10 were White, 13 were African American, and 3 were Hispanic. On the other hand, Ms. Anthony’s pre-algebra class contained a majority of White students with 23 White students, only 1 African American, and 2 Hispanics.

Ms. Anthony was attempting to incorporate *Standards*-based teaching practices on a daily basis. As a change from her first year of teaching, her teaching practices had reverted to more traditional practices. Her desks in the classroom were no longer in groups but back in rows. Ms. Anthony still made a conscious effort each day to incorporate effective questioning techniques and to be more of a facilitator of student discussion. When her students worked in groups, they generally discussed homework problems without formal group guidelines and did not participate in investigative activities.

Ms. Anthony still had very strong beliefs that *Standards*-based teaching was the best approach for equitable and effective student learning. She was not incorporating the practices to the extent she really wanted. However, she no longer had guilt feelings about her practices but acknowledged that flexibility required some accommodations to *Standards*-based teaching. Ms. Anthony’s flexibility was necessary because of several factors that influenced her teaching practices. The main deterrent to incorporating *Standards*-based strategies was the county’s policy of covering all of the objectives of the course of study in seven months. This policy did not mix with the investigative nature of *Standards*-based practices, which most of the teachers at North Junior High School did not support. Closely related to the curriculum policy was the issue of high-stakes testing. The students had to receive exposure to each concept in the course of study by testing time in April. To make matters worse, one lesson out of ten was dedicated to “practicing” for the high-stakes tests in the computer lab. These factors coupled with Ms. Anthony’s difficulty with classroom management presented a rather formidable roadblock to *Standards*-based teaching practices.

Ms. Anthony’s approach to teaching was somewhat different for her two different levels of classes. The actual cause of the difference is complicated. The primary reason that she adjusted her teaching practices entailed the less controlled atmosphere of the basic mathematics class. However, Ms. Anthony also admitted her doubts toward the appropriateness of presenting mathematics topics conceptually to her basic mathematics class. She did not feel that the basic mathematics class could comprehend a conceptual approach. If Ms. Anthony could get a handle on the behavior of the classroom and not have the constraints

of a 7-month curriculum, her teaching practices would definitely align more closely with *Standards*-based teaching practices.

*Case 5: Ms. Chandler*

Ms. Chandler was in her fifth year of teaching but only her second at South City High School. Ms. Chandler was an enthusiastic young White teacher who always had a smile on her face. Ms. Chandler, a more seasoned teacher, was the only case study participant with a bachelors and masters from Southern State University. She served as both a school teacher leader and a presenter for CTM. South City required all mathematics teachers to attend the CTM summer institute, but the administration was ambivalent toward *Standards*-based teaching practices that CTM promoted.

Even though the school had a very challenging academic curriculum, all of Ms. Chandler's classes were composed of students who were labeled as "low-achieving." Ms. Chandler enjoyed teaching the slower-paced classes and requested these classes each year. Ms. Chandler taught two sections of geometry and one section of algebra II without trigonometry. Even though South City High used a traditional curriculum, Ms. Chandler frequently supplemented the curriculum with investigative activities. Ms. Chandler was provided a tablet computer that connected to a LCD projector.

Ms. Chandler arranged her desks neatly in rows, but the positioning for the first desk in each row was marked by an "x." The "x" marked the spot so that the desks could easily be put back in rows after the students had been working in groups. The incorporation of the graphing calculator was an integral part of her teaching. She used it to explore, justify, and connect mathematical concepts. Ms. Chandler felt that she should take on the cause for the so-called "low-achieving" students that most teachers preferred not to teach. She took special steps to make sure that these students were successful. One effective technique included assigning students problems to present a day early so that they could be prepared. She pointed out that presenting the concepts in several different ways reached out to students with different learning styles. Ms. Chandler wanted to make sure that her students made connections between mathematical concepts and understood what they were learning. Ms. Chandler also believed that supporting the students by attending their extracurricular activities improved the rapport between teacher and student.

Ms. Chandler exhibited an excellent model of *Standards*-based teaching practices. She effectively incorporated investigative-type activities, and all of her students presented findings to the class. An air of openness and safety was apparent in the classroom, and student-to-student discussions were common. Ms. Chandler was content to be a facilitator that provided the necessary support for effective student learning. Ms. Chandler's beliefs were in total alignment with her *Standards*-based teaching practices. Ms. Chandler had a very strong personality and overcame any obstacles to teaching using *Standards*-based strategies. The student demographics of her class would certainly be a deterrent to many mathematics teachers, but Ms. Chandler gladly accepted the challenge with high expectations for of her all

students. Neither her internship, nor her school's faculty, nor administration was particularly supportive of *Standards*-based teaching, but she did not succumb to any political pressures and stayed true to her beliefs. Her high level of involvement with the CTM systemic project provided a support system for her beliefs and practices that helped fill the gap caused by the lack of support in her school environment.

### Conclusion

In the different case studies, the teaching styles varied considerably. In all facets of teaching, Mr. Easterly exhibited a very traditional style of teaching. Similarly, Ms. Danforth followed a traditional teaching pattern with few diversions. Mr. Barry incorporated conceptual explanations, student presentations of homework, and student discussions that were representative of *Standards*-based teaching. However, the thrust of his lessons involved direct teaching and not inquiry-based learning. Ms. Anthony attempted to incorporate *Standards*-based teaching practices with the investigative activities, real-world problems, and effective questioning. Ms. Anthony's classroom still had many characteristics of teacher-centered teaching. In her second year of teaching, Ms. Anthony reduced the number of group activities and became more resigned to using more traditional teaching methods. Ms. Chandler's classroom had a distinctively different feel to it—the focus was on the students, and Ms. Chandler was their facilitator. She provided a real-life textbook illustration of the guidelines of the *Standards* in all of her classes. The overall picture shows that teachers were teaching in a traditional teacher-centered style, and some teachers were incorporating certain aspects of the *Standards*-based methods. Ms. Chandler was the exception.

A synopsis of the relationship of the teachers' beliefs and practices suggests that they held beliefs that aligned with their teaching practices with the exception of Ms. Anthony. In fact, three case study teachers' beliefs and practices were at opposite extremes in the TPBS and were questioned specifically about the differences in their interviews. These three teachers were able to explain that the beliefs actually did align with their practices and illustrated Leatham's (2006) theory that teachers organize beliefs into systems that are logical to them.

This study showed that many factors influence teachers' practices. The threat of job security that an administrator holds is very powerful, and that authority impacted the teachers in this study. In connection with administrators, inquiry-based teaching requires time for students to develop their own ideas, and teachers in this study felt pressure to stay on track with their school's pacing guide. This pressure was intensified because of the importance of preparing students for high-stakes testing and the danger of their schools not attaining Adequate Yearly Progress. Additionally for Mr. Barry, the objectives of his curriculum were not in alignment of the guidelines of the *Standards*. Finally, the difficulty of managing students' behavior or even the threat of the students becoming unruly had a significant impact on teachers' practices in this study.

Of the five case studies, only Ms. Chandler incorporated *Standards*-based strategies at a high level. Ms. Anthony was striving to utilize *Standards*-based teaching practices that hopefully would improve each year as her classroom management improved. With the exception of Ms. Anthony, the mathematics teachers felt that their beliefs were in alignment with their teaching practices. Several influences were instrumental in affecting participants' teaching practices. Classroom management was a factor to some extent for all five teachers. The outside influences of administration, curriculum, high-stakes testing, and colleagues were also very strong. Apart from Ms. Chandler, all of the case study participants were influenced by student demographics. The most influential demographic factors were the socioeconomic status of students and the perceived ability level of students.

An effective *Standards*-based pre-service education does not offer any guarantee that teachers will promote the guidelines of the *Standards* when they become classroom teachers. Often teachers do not hold *Standards*-based beliefs and incorporate *Standards*-based practices because they are heavily influenced by the traditional climate of their surroundings coupled with past childhood educational experiences. However, some teachers' beliefs become aligned so strongly with the *Standards* that they are determined to be facilitators in a student-centered classroom regardless of the obstacles. Ms. Chandler provided an example such commitment and determination.

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