AN EVALUATION OF A 4 – 8 MATHEMATICS TEACHER PREPARATION PROGRAM AT A LARGE STATE INSTITUTION IN TEXAS

A Dissertation Presented to the
Faculty of the College of Education
University of Houston

In Partial Fulfillment
of the Requirements for the Degree

Doctor of Education

by

Woong Lim

August, 2011

AN EVALUATION OF A 4 – 8 MATHEMATICS TEACHER PREPARATION PROGRAM AT A LARGE STATE INSTITUTION IN TEXAS

A Dissertation for the Degree

Doctor of Education

By

Woong Lim

Approved by Dissertation Committee:

Dr. Jennifer Chauvot, Chairperson

Dr. Jacqueline Hawkins, Committee Member

Dr. Melissa Pierson, Committee Member

Dr. Lilia Ruban, Committee Member

Dr. Robert H. McPherson, Dean
College of Education

August, 2011

ACKNOWLEDGEMENT

I would like to thank my parents, Chae-ho and Jung-hyun for their unconditional love. I would also like to thank my dissertation committee members, Dr. Jennifer Chauvot (the chair), Dr. Jacqueline Hawkins, Dr. Melissa Pierson, and Dr. Lilia Ruban. I am in awe of their wisdom, expertise, and dedication to teacher education.

I extend to Dr. Chauvot (my advisor) my heartfelt thanks. She has been seminal in shaping my scholarship. She was there every step of the way guiding me and encouraging. Thank you, Jen!

AN EVALUATION OF A 4 – 8 MATHEMATICS TEACHER PREPARATION PROGRAM AT A LARGE STATE INSTITUTION IN TEXAS

An Abstract
of A Dissertation Presented to the
Faculty of the College of Education
University of Houston

In Partial Fulfillment of the Requirements for the Degree

Doctor of Education

by

Woong Lim

August, 2011

Lim, Woong. "An Evaluation of a 4 – 8 Mathematics Teacher Preparation Program at a Large State Institution in Texas." Unpublished Doctor of Education Dissertation, University of Houston, August, 2011

Abstract

Teacher education programs are in need of data-driven systematic program evaluations to discuss the status quo of the program and to reflect upon ways to improve pre-service teachers' learning. This study provided a springboard for future teacher preparation evaluation studies by examining the 4 – 8 mathematics teacher preparation component of the teacher preparation program at a large state institution in Texas. The research questions for this study were: (1) To what extent is the 4-8 mathematics teacher preparation program consistent with state standards for mathematics teacher preparation? (2) What content and pedagogical content knowledge can 4-8 mathematics pre-service teachers demonstrate at their respective points in the program? (3) What are the pre-service teachers' perceptions of preparedness for teaching mathematics?

The first research question was addressed by conducting a document analysis of course syllabi and learning resources available on the course websites. A TExES matrix was developed and used to examine how well the courses in the program aligned with the state standards. A paper/pencil assessment called Diagnostic Mathematics Assessments for Middle School Teachers (DTAMS) was used to answer the second research question. The third research question was addressed by examining students' written responses from an anonymous web-based survey. Included in the study were 4-8 mathematics certification students who were enrolled in the content, method, and student teaching

courses Fall 2010 – Spring 2011. Twenty nine pre-service teachers participated and completed DTAMS testing. Twenty three pre-service teachers completed the anonymous survey.

The study reported the following outcomes. First, the study found that the mathematics courses met state standards covering about 83% of the mathematics-related TExES learning outcomes and mathematics education courses met standards covering all mathematics education-related TExES learning outcomes.

Second, the study found that pre-service teachers in the content and method courses displayed the strongest knowledge in Number Computation, followed by Algebraic Ideas, Geometry/Measurement, and Probability/Statistics. Pre-service teachers displayed the highest scores for Memorized/Factual Knowledge, followed by Conceptual Understanding, Reasoning/Problem Solving, and Pedagogical Content Knowledge. Pre-service teachers had higher Memorized/Factual Knowledge than Pedagogical Content Knowledge. The pre-service teachers' overall content knowledge was not strong, and the two lowest-performing content knowledge areas were Geometry/Measurement and Probability/Statistics.

Third, the study found that pre-service teachers did not feel that they were well prepared in Probability/Statistics and Geometry/Measurement, and that pre-service teachers did not demonstrate a clear pattern for the program's coverage of the other strands. Pre-service teachers' written responses provided the following themes: (1) Pre-service teachers had low confidence in content knowledge, (2) Pre-service teachers wanted early exposure to pedagogy in the program coursework, and (3) Pre-service teachers wanted to learn to connect theory with practice.

Overall, the picture emerging from this study was of (1) pre-service teachers dedicated to teaching yet demonstrating low knowledge of content and pedagogy and of (2) the program in difficulty of building a pedagogical prowess upon low confidence and knowledge in mathematical content. The study recommends future studies about how the intended curriculum is being implemented and about the process of pre-service teachers' learning of college mathematics.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

CHAPTER ONE

Introduction

With the enactment of the No Child Left Behind Act (NCLB) in 2001, the demand for highly qualified teachers increased, and teacher accountability has become the subject of debate. The emphasis in teacher accountability has caused schools of education to restructure their teacher education programs in order to improve teacher quality (Evers & Walberg, 2002). Mathematics teacher education programs align goals and objectives with national recommendations regarding mathematics teaching. The National Council of Teachers of Mathematics publication of *Principles and Standards for School Mathematics* (NCTM, 2000), an offspring of the *Curriculum and Evaluation Standards* (NCTM, 1989) substantiated standards-based instruction. The documents have initiated standards for what mathematics should be taught and have become a critical part of the standards-based reform movement (Robinson, Robinson, & Maceli, 2000). The essential characteristics of a standards-based classroom include emphasizing mathematical inquiry and reasoning, developing students to become effective problem solvers and able to communicate their mathematical ideas, and creating learning environments in which the teacher is more of a facilitator of learning than a dispenser of knowledge (Graham & Fennell, 2001; NCTM, 2000). In this way, the *NCTM Standards* have changed the perceptions of what pre-service mathematics teachers ought to experience in teacher education programs (Hiebert, 2003).

Some researchers have believed that pre-service mathematics teachers have knowledge that allows them to teach traditional mathematics but that this knowledge is not deep enough to teach mathematics consistent with the *NCTM Standards* (Heaton, 2000; Frykholm, 2005; Latterell, 2008). Thus, researchers and educators have been designing teacher preparation programs that focus on inquiry, reflection, and learning to develop a knowledge base of professional teaching practices adherent to state and national standards (Darling-Hammond, 2006; Graham & Fennell, 2001; Heaton, 2000). For example, some teacher education programs have begun to emphasize the change of pre-service teachers' beliefs about teaching and learning mathematics as a significant component of learning outcomes; furthermore, some have redesigned their curriculum such that general mathematics courses are in alignment with mathematics education courses that are consistent with the *NCTM Standards* (Liljedahl, Rolka, & Rösken, 2007; Taylor, 2002).

Such changes call for new research on the results of the teacher education program's work for improvement as well as how teacher preparation programs develop and sustain systematic evaluations. Although there has been constantly changing criteria for judging an effectiveness of teacher education programs, research does suggest that program evaluations be based on evidence of pre-service teachers' learning (Hall, Smith, & Nowinski, 2005). Research supports the use of multiple measures on the various elements in teacher education programs to draw a comprehensive picture of what pre-service teachers learn and how a program contributes to their performance (Darling-Hammond, 2006). The National Council for Accreditation of Teacher Education (NCATE, 2002) standards ask for evidence that pre-service teachers are actually learning as they progress through the teacher education programs and whether or not the graduates of programs are prepared to have an impact on student learning (Hall, Smith, & Nowinski, 2005).

This study conducted an evaluation of the 4-8 mathematics education component of the teacher preparation program at the University of Houston called Quality Urban Education for Students and Teachers (QUEST). The study collected information about pre-service teachers' knowledge and their learning through various measures. It examined how the program met state standards established for teacher preparation, and it provided recommendations for ways to improve upon the program and avenues for future evaluation studies.

Need for the Study

The demands of state and federal accountability systems on teacher quality make it imperative that teacher educators find productive ways to systematically evaluate their education programs' outcomes. Most universities have had some aspect of reform-based teaching practices in their programs (Bristor, Kinzer, Lapp, & Ridener, 2002). However, there has not been a consistent and shared framework for organizing the many variables that comprise teacher education practice and relating these to evidence of effectiveness. Only more recently have education researchers developed an organizing framework for systematic evaluation of teacher education programs with a renewed focus on collecting evidence of outcomes of pre-service teachers' learning (Dean & Lauer, 2003; Hall, Smith, & Nowinski, 2005). The vision of developing a comprehensive framework is that there is increased clarity about how program evaluation should be conducted, and that data-driven systematic program evaluations guide teacher educators to validate their innovative approaches or consider a new direction if necessary (Hall, Smith, & Nowinski, 2005).

For this study, collecting data about pre-service teachers' content and pedagogical content knowledge against professional standards of practice, in conjunction with other elements of innovative teacher education programs offer new insights about a systematic evaluation of the mathematics education component of a teacher certification program.

Statement of the Problem

High teacher quality is a key element in improving public education in the United States (Allgood & Rice, 2002). It has become a national priority to supply effective teachers for our students (Rice, 2009). Although the federal government increased the accountability for schools, this law equated teacher quality with teacher qualification; some teachers who were qualified were actually not adequately equipped with appropriate mathematical knowledge for teaching (Ball, Sleep, Boerst, & Bass, 2009). In addition, the No Child Left Behind Act, in describing teacher quality, was criticized for overemphasizing content knowledge and disregarding other key dimensions of teacher quality, such as pedagogy and reflective inquiry (Rothstein, 2008).

Multiple curricula packages have been developed for standards-based mathematics instruction. These curricula packages include instructional guidelines and strategies as recommended by the NCTM documents. Although these packages emphasize mathematical thinking and reasoning with problem solving skills, and are meant to engage students by connecting with what they already know, mathematics teachers continue to have difficulty following the recommendations for teaching these curricula in their classrooms (Frykholm, 2004; Grant & Kline, 2000; Hiebert, 2003).

In light of the stated problems, many teacher education programs changed their curricula so that program coursework support the NCTM documents; such programs took on the primary responsibility for guiding pre-service teachers in increasing the type of teacher knowledge that can bring sustainable impact on changing traditional classroom practices (Frykholm, 2005; Graham & Fennell, 2001). However, this effort has seldom been evaluated empirically using viable measures (Ball, Lubienski, & Mewborn, 2001). Emerging research provides new perspectives and methodologies for gathering, interpreting, and reporting evidence about program improvement (Hall, Smith, & Nowinski, 2005). Research about the current state of pre-service teachers' knowledge of mathematics and its teaching at the appropriate certification level as part of an ongoing systematic evaluation of a teacher education program could add more to the current body of literature about teacher education program evaluations.

Purpose of the Study

The purpose of the study was to provide a springboard for future teacher preparation evaluation studies by taking a snapshot of 4-8 mathematics pre-service teacher knowledge at their respective phases of QUEST and considering the pre-service teachers' perceptions of preparedness for teaching mathematics as part of ongoing efforts to conduct appropriate teacher education program evaluations. The first step was to look at the coursework of the program in order to determine ways in which the current program aligns with the state standards. The next step was to collect evidence regarding what pre-service teachers know about mathematics and its teaching at their respective points in the program. In addition, the study incorporated pre-service teachers' voice in drawing a current snapshot of the program by conducting an anonymous survey of pre-service teachers' perceptions of preparedness and recommendations.

Research Questions

The following research questions guided this study:

Research Question One. To what extent is the 4-8 mathematics teacher preparation program consistent with state standards for mathematics teacher preparation?

Research Question Two. What content and pedagogical content knowledge can 4-8 mathematics pre-service teachers demonstrate at their respective points in the program?

Research Question Three. What are the pre-service teachers' perceptions of preparedness for teaching mathematics?

CHAPTER TWO

Review of Literature

This study was a first step towards the ongoing efforts of the teacher educators at the University to improve the mathematics teacher education program. The overarching purpose of the study was to conduct an evidence-based evaluation of the mathematics education component of the teacher education program and provide a springboard for future teacher preparation evaluation studies. This study first, reports to what extent the current 4 – 8 math QUEST program courses are consistent with state standards. Second, this study was interested in offering a snapshot of 4-8 mathematics pre-service teacher knowledge at their respective phases of QUEST by utilizing the outcomes of assessments that measure content and pedagogical content knowledge for middle school mathematics teachers and through survey data on pre-service teachers' perceptions of preparedness. Finally, the study provides recommendations for improvement of QUEST.

This chapter provides a review of literature specific to mathematics teacher preparation. It describes studies regarding standards-based reform in mathematics education and what mathematics education researchers say about effective teachers' teaching practices; it also addresses literature about how mathematics education researchers have conceptualized teacher knowledge, such as pedagogical content knowledge (PCK) and mathematical knowledge for teaching (MKT). This in turn highlights the recommended learning outcomes for mathematics teacher preparation programs. Literature about innovative teacher education programs, alignment with standards, and systematic evaluations with a renewed focus on pre-service teachers' learning is also discussed. In light of evaluating a teacher education program using a PCK assessment, recent research about using an MKT assessment to measure teachers' preparedness for teaching is presented. In addition, examples of teacher education programs that used their pre-service teachers' pedagogical capacity as an integral part of evaluation are presented.

Standards-based Reform in Mathematics Education and Quality Teaching

Mathematics education's current reform effort has been called standards-based reform, which includes setting clear standards for student outcomes (Goldsmith & Mark, 1999). The standards-based reform represented a shift from rote and passive learning to an emphasis on sense making of mathematics through active discourse with students. It also delineated what teachers need to know to teach toward the standards to increase student achievement (Riordan & Noyce, 2001; Robinson, Robinson, & Maceli, 2000).

The *NCTM Standards* represented a vision of teaching mathematics that was different from a traditional teacher-centered perspective. The *Standards* serve as a broad framework to guide reform in school mathematics that supports the necessary pedagogical and curricular changes (Graham & Fennell, 2001; Riordan & Noyce, 2001). Debellis and Rosenstein (2007) report that pre-service teachers often consider mathematics as a set of facts and procedures and attribute their lack of success in mathematics to their inability to remember the formulas and techniques; they often define teaching mathematics as transmitting those facts and procedures to their students. On the other hand, Mewborn and Cross (2007) provided a list of standards-based classrooms that align with *Principles and Standards for School Mathematics* (NCTM, 2000): (1) Mathematics is problem solving; (2) The goal of doing mathematics problem is to make sense of the problem, the solution process, and the answer; and (3) In the teaching-learning process, the student and teacher are both active in making sense of the mathematics and of students' reasoning.

Regarding the relationship between standards-based mathematics instruction and student achievement, some research studies report that students taught through standards-based curricula achieved higher gains than students taught with a traditional curriculum, and that the performance gaps between majority and minority students as well as between students from low socioeconomic families and students from high-socioeconomic families are reduced (Hiebert, 2003; Riordan & Noyce, 2001; Vogler, 2002). Studies about effective teaching report that effective teachers' classroom practices are very similar to standards-based classroom practices (Hiebert, Morris, Berk, & Jansen, 2007; Heaton, 2000; Larson, 2002). Effective teachers have appropriate content knowledge; their teaching practices focus on enabling the students to make sense of mathematical properties or concepts while cultivating discourse in which their students communicate mathematical ideas (Berliner, 2004; Heaton, 2000). Furthermore, a recent study (Ball & Foranzi, 2009) finds that not only do effective teachers have appropriate content knowledge but also they enable others to learn, think, and do mathematics, and that teaching involves identifying ways students are thinking about the problem, devising the next steps in the students' development, and assessing the learning progress.

However, research about pre-service teachers in mathematics reported that pre-service teachers have a medium-level of commitment to the *NCTM Standards* (Frykholm, 1996; Latterell, 2008). It concluded that pre-service programs need to ensure that teacher candidates experience meaningful learning opportunities consistent with NCTM-oriented mathematics curricula (Frykholm, 1996; Frykholm, 1999). In other words, while the field of mathematics education has moved toward a new vision of mathematics teaching practices that has been shown to influence learning outcomes in a positive way, pre-service mathematics teachers (the next generation of mathematics teachers) do not necessarily share this vision. Teacher preparation programs in part need to focus on this gap.

Over a decade since the 2001 NCLB, there has been a strong demand on increasing student performance in high-stake benchmark tests, thus there is a high need for recruiting effective teachers who can impact student learning to produce higher test scores (Murnane & Steele, 2007). Previously, most of the foundational work on teacher knowledge has been quantitative in orientation, and researchers sought to measure teachers' knowledge more directly by looking at teachers' performance on certificate exams or other tests of subject-matter competence (Fabiano, 1999). For example, one study administered the same fourth-grade math assessment to both teachers and students, using the teachers' group to predict performance among their students (Harbison & Hanushek, 1992). Another study used teachers' scores on a primary-school-leaving examination (Mullens, Murnane, & Willett, 1996). However, such measures of teacher quality did not identify the process through which student achievement was linked to teacher characteristics; that is, it did not examine how the teachers' knowledge play out in classroom as well as individual teacher's effort to improve instructional practice (Smith, Desimone, & Ueno, 2005). Ball, Hill, and Bass (2005) presented a host of challenges in measuring teacher quality and cautioned against the excessive dependence on quantitative data. Some researchers called for more work on a shared framework about the knowledge for teaching mathematics (Ball, Lubienski, & Mewborn, 2001; Borko & Whitcomb, 2008).

Conceptualizing Knowledge for Teaching Mathematics

Mohr (2006) reported that there is a difference between the mathematics knowledge needed to be an effective teacher and that needed by a research mathematician. The mathematical knowledge needed for teaching mathematics is different from the mathematical knowledge taught in university mathematics classes, and the number of university mathematics courses taken by a mathematics teacher had been found to have little impact on student achievement (Wayne & Youngs, 2003). Ma (1999) reported that U.S. teachers were proficient at carrying out mathematical procedures, but often could not come up with appropriate illustrations of mathematical concepts; that is, they knew what to do to carry out an algorithm, but could neither explain to students why the procedures they prescribed worked nor make connections to the related mathematical ideas. Research also found that large number of mathematics teachers with quantitative skills had difficulty teaching with standards-based curricula when they lacked the knowledge of students' understandings and their typical misunderstandings (Heaton, 2000). Additionally, it is found that elementary students struggled with making conceptual connections to mathematical ideas, and that such a difficulty could be attributed to the teacher’s difficulty with conceptual understanding (Ball, Hill, & Bass, 2005).

Beyond the scope of traditional mathematical content knowledge. Research implies that one of the more significant links between effective teaching and student achievement is that highly qualified teachers have more capacity and willingness to construct effective curricular materials for their students (Ball & Feiman-Nemser, 1988). Effective mathematics teachers do know mathematics well. More importantly, they are fascinated with how students think, and they understand that mathematics is not only a record of knowledge and skills but also a set of ideas and thoughts developed by the learners (Kuhs & Ball, 1986). To be more specific, effective teachers (1) enjoy doing mathematics themselves; (2) think of their role as a teacher not so much as centrally directing learning and providing information but as facilitating meaningful student exploration; and (3) believe that they can improve teaching by feedbacks from students and colleagues, and that learning to teach mathematics is a lifelong process. Indeed, a large body of studies indicates that the standards-based mathematics instruction results in students achievement gain when the standard-based curricula are taught by teachers who are knowledgeable, beyond the scope of traditional mathematical content knowledge, about students and pedagogical strategies (Darling-Hammond, 2006; Weiss et al., 2003). Research implies that mathematics content knowledge is a necessary but not sufficient condition for effective mathematics teaching (Monk, 1994). As a result, a new set of research was developed within the broader question of how pre-service mathematics teachers develop this new teacher knowledge that is different from traditional content knowledge and what experiences pre-service mathematics teachers should have in teacher education programs (Morris, Hiebert, & Spitzer, 2009; Taylor, 2002; Wilson & Ball, 1996).

Pedagogical content knowledge (PCK) and mathematical knowledge for teaching (MKT). Studies show that effective teachers consider multiple ways of representing a mathematical problem and have the kind of special knowledge base consisting of integrated and related facts and rules, whereas novice teachers focus on solutions to a problem and knowledge consisting of disconnected ideas, facts, and rules (Grossman, 1990; Zimmerlin & Nelson, 2000). Researchers have conceptualized a special knowledge for teaching mathematics and progressively developed the notion of pedagogical content knowledge (Mohr, 2006). Shulman (1987) coined the term, pedagogical content knowledge (PCK), which is specific content knowledge as applied to teaching. He suggested distinguishing among three categories of content knowledge: (1) subject matter content knowledge, (2) pedagogical content knowledge, and (3) curricular knowledge. Subject matter content knowledge is an understanding of the information and concepts within a particular domain, which includes a mastery of computational skills, procedures, and a conceptual understanding of mathematical truth in the discipline (Sherin, 2002; Shulman, 1987). Teachers with appropriate subject matter content knowledge should be able to define for students the accepted truths in a domain and explain how a particular proposition is proved, why it is worth learning, and how it relates to the other propositions (Darling-Hammond, 2000). Pedagogical knowledge goes beyond subject matter content knowledge only to include presenting multiple representations of the ideas, analogies, illustrations, examples, explanations, and, in essence, making the subject comprehensible to others (Shulman, 1987). Developed with secondary teaching of various school subjects, Shulman (1987) defined pedagogical content knowledge as the ability of the teacher to transform the content knowledge into a special kind of teacher knowledge that links content, students, and pedagogy. His notion of PCK contributed to the growing body of research literature on teacher knowledge.

A mathematics teacher with high PCK anticipates misunderstandings in specific instructional contexts and appropriately employs various strategies to aid the student in developing proper understanding. Schoenfeld (2007) suggested that this type of PCK was different from mathematics knowledge in that mathematics knowledge does not consider anticipating student errors. Such capacity and knowledge that may merit little attention for mathematicians are, in fact, the key dimensions of a construct called as mathematical knowledge for teaching. Influenced by the notion of PCK, Ball and her colleagues developed the definition of mathematical knowledge for teaching (MKT) as a particular type of mathematical knowledge for carrying out the work of teaching mathematics (Ball, 1999; Hill, Rowan, & Ball, 2005).

The use of a PCK or MKT assessment. Hill, Schilling, and Ball (2004) asserted that there were no specific measures of teachers' pedagogical capacity in place in mathematics education, and that measures of teachers' mathematical knowledge for teaching should be content specific as well as specific to the teaching of an appropriate grade level. Hill, Rowan, and Ball (2005) pointed out that if teachers' knowledge were not adequately measured, any following research might not make appropriate conclusions about the effect of teachers' knowledge on student learning.

Effectiveness in teaching resides not simply in the knowledge a teacher has accrued, but in how this knowledge is used in classrooms (Hill, Rowan, & Ball, 2005). With this in mind, assessing teachers through performance on tests of basic verbal or mathematics ability may overlook other key elements in quality teaching (Borko & Whitcomb, 2008). Based on the hypothesized domains of MKT (common content knowledge, specialized content knowledge, knowledge of content and students, and knowledge of contents and teaching), Hill, Rowan and Ball (2005) developed multiple-choice items on topics, such as number, algebra, and geometry to measure elementary teachers' MKT. The test items were centered directly on the content of the K-6 curriculum rather than items on a middle school or high school exam. In models that used scores for first and third graders as the dependent variables, Ball and her colleagues have succeeded in identifying a positive correlation between MKT and student achievement (Hill, Rowan, & Ball, 2005). This provides a theoretical framework supporting the use of a PCK or MKT assessment as a viable measure for evaluating teacher education programs. Ball and her colleagues found that, at the elementary level, teacher's mathematical knowledge for teaching could predict math achievement, and that the subjects' MKT was not related to their teaching or math ability (Hill, Rowan, & Ball, 2005; Hill, Schilling, & Ball, 2004). In this way, the measure developed by the Ball's study group (2005) could produce the kind of quantitative data that served as empirical evidence to describe the impact of MKT on students' academic achievement. The study also found that teachers' preparation, credentials, and years of experience are only modestly related to performance on the content knowledge measures.

Other measures of teacher knowledge include Knowing Mathematics for Teaching Algebra (KAT), which was developed at Michigan State University. This set of assessment items was designed to measure mathematical knowledge for teaching algebra among pre-service and in-service secondary school mathematics teachers in large-scale settings. This assessment aimed to study the status and variation of teacher knowledge. The Diagnostic Mathematics Assessments for Middle School Teachers, developed at the University of Louisville, are 20-item assessments designed to measure teacher content and pedagogical content knowledge in four content strands: Number Concepts, Algebra, Geometry and Probability, and Statistics. Finally, the Teacher Education and Development Study in Mathematics (TEDS-M) used three item formats to assess both mathematics content knowledge and mathematics pedagogical content knowledge (Tatto et al., 2008). The study reported that the mathematics content knowledge scale and the mathematics pedagogical content scale appeared to be different dimensions of mathematical knowledge for teaching (Tatto et al., 2008). The TEDS-M (2008) further reported that there existed a number of challenges related to measuring MKT: (1) motivating future teachers to participate in the research, (2) content validity of the items, (3) reliability of scoring of the items; and (4) identification and delineation of the hypothesized dimensions of MKT.

The assessments identified above represent the beginning of deliberate and careful attempts to measure the kind and quality of teacher knowledge needed to implement teaching practices that are consistent with the *NCTM Standards.* The assessments attend to different grade bands, different mathematics content areas and different levels of expertise. More work is needed to come to a comprehensive understanding of mathematics teacher knowledge and how to assess it. This understanding is critical for the design and implementation of effective mathematics teacher preparation programs.

Innovative Teacher Education Programs

Teacher education programs receiving high satisfactions from their graduates have common components (Darling-Hammond, 2006). These components emphasize the development of courses designed to build a professional knowledge base connecting different strands of teaching tasks to student learning, develop knowledge of content and pedagogy, and develop an understanding of the growing complexity in educational purposes and related issues (Darling-Hammond, 2003). Research suggests that applying teachers' mathematics knowledge alone does not always present a solution to actual teaching situations, and that teachers need to develop education of applying their content knowledge by synthesizing their understanding of curriculum and student learning (Sherin, 2002), which precisely points to the attainment of pedagogical capacity. Similarly, Schoenfeld (2007) asserted teacher education programs should examine what it takes to achieve a true sense of pedagogical competency and use the knowledge to adequately prepare pre-service teachers. Taylor (2002) recommended that pre-service teachers discuss current research on effective teaching and grow professionally in a cohort with other pre-service teachers. Some studies assert that examining the nature of the classroom practice of effective teaching through video-taping and classroom visits can be used as a starting point for designing effective teacher education programs (Wilson & Ball, 1996). Gómez and Rico (2004) claimed that the pre-service teachers need to join a community of teachers whose teaching are in line with the standards in order to practice the standards-based teaching. To be more specific, Kinach (2002) suggested that the coursework of a teacher education program that supports the *NCTM Standards* should focus on the process in which pre-service teachers and the instructor must work together as a team to negotiate criteria for good instructional explanations to heighten mathematical knowledge for teaching as well as to debate the characteristics of meaningful learning. In this way, one of the important common visions of teacher preparation programs is working together to seek consensus about effective teaching through discourses and bring a meaningful change in pre-service teachers (Braun & Crumpler, 2004).

Evaluation in Teacher Preparation Programs

During the 1980s, teacher education evaluation used single data sources such as graduate exit surveys, ratings by principals of first-year teachers, and graduate employment rates (Peterson, 1989). Peterson (1989), however, recommended an alternative set of resources, such as peer review of materials, student reports, parent surveys, teacher tests, documentation of professionalism, student achievement data, systematic observation, and administrator reports. In the 1990s, teacher education program evaluations were performed by examining the knowledge base of faculty and courses or the mastery of conceptual themes of programs (Hall, Smith, & Nowinski, 2005). Meanwhile, Diez (1998) argued that teacher education programs should gather evidence of effectiveness by specifying the outcomes of the program, measuring the development of student learning outcomes, involving faculty across the institution in the process, and implementing program evaluations as an ongoing activity. In addition, Howey and Zimpher (1999) suggested that teacher education programs measure the nature of pre-service teachers' development as teachers by rating the performances of the pre-service teachers' K-12 students. At that time, there has been an increased interest in continuous improvement models in which program evaluation is viewed not as an administrative project for accreditation but as an ongoing effort to develop new measures and making changes (Henn-Reinke & Kies, 1998). As an ongoing effort to gather and disseminate systematic evidence about effective teacher education, the Teacher Education

Initiative (TEI) at University of Michigan developed an integrated assessment system in elementary mathematics teacher education. TEI documents state that the program culture supports data collection and its use for evaluation, analyzing effective teaching practice, giving feedback, and increasing an understanding across different stake-holders about how to collaborate for the preparation of quality teachers. In 2007, the program started a project titled, Developing an Integrated Assessment System for Elementary Teacher Education (DIAS). DIAS focused on assessment in mathematics education courses and how the teaching affects pre-service teachers in field experience and the first year of teaching. The project indicated that constructing and using valid and reliable assessments of teaching was a challenging task but was crucial part of the consistent system to figure out what practices in the program to keep and how to improve. Additional finding was that evaluating a teacher education program should not only examine whether pre-service teachers are increasing pedagogical capacity and but also ascertain how the program operates within the shared responsibilities that encourage involvement and build commitment from both faculty and administrators of the program.

Current efforts to improve teacher education program evaluations. Currently, the *NCATE Standards* focus on assessment of pre-service teachers' in terms of their development toward becoming quality teachers and on how well the components of a teacher education program are in sync with one another for this goal (NCATE, 2002); programs address the impact of graduates on their students by adhering to the standards that defines effective practice in terms of desired learning outcomes. Yinger and Hendricks-Lee (2000) argue that the *NCATE Standards* are essential in evaluating the quality of teaching against an established professional knowledge base and that there is a wide support of accountability for teacher preparation through collecting evidence of effectiveness.

In order for teacher educators to successfully implement state and national standards, the alignment of standards with instruction and assessment is key to standards-based teacher preparation (Goos & Moni, 2001). A systematic alignment process with standards is to draw a roadmap that links learning outcomes to setting the expectations for both instruction and assessment (Baker, 2004). A course with alignment of standards for *instruction* has scope and sequence documents that identify which knowledge and skills are to be taught as well as where in the learning resources these skills are covered (La Marca, Redfield, & Winter, 2000). A course with alignment of standards for *assessment* needs to document how each item on test or a task measures the intended learning outcomes and addresses the degree of cognitive complexity in assessment (Herman, Web, & Zuniga, 2005).

Moreover, emerging research suggests that there is a paradigm shift in teacher education program evaluations from focusing on what or how things should be taught for per-service teachers, to thinking about what pre-service teachers are actually learning or what they express about the learning process, so that teacher educators can make appropriate changes for improvement of their education programs (Darling-Hammond, 2003; Hall, Smith, & Nowinski, 2005).

There are some reports regarding evaluation of teacher education programs using multiple strategies for evaluating the outcomes of teacher education. Cochran-Smith (2001) identifies three major data sources for learning outcomes of teacher preparation programs, which include (1) K−12 student achievement, (2) candidates’ scores on standardized teacher content knowledge tests, and (3) documentation of performance assessments of teacher knowledge and skills during the various phases of the preparation program. Satisfaction and feedback surveys from pre-service teachers and graduates of teacher education programs are also recognized as key components of the teacher education accreditation process (NCATE, 2002). Diez (1998) argues that teaching and learning can improve by the feedback for improvement in relation to the outcomes of teacher education. Research provides an example in which a survey instrument indicated that elementary student teachers were not feeling confident in teaching certain topics and their competency testing on the topics also echoed the same conclusion; however, this information was instrumental in assisting the program in changing the course sequence as well as increasing the content knowledge requirements (Darling-Hammond, Eiler, & Marcus, 2002). Studies also reported that pre-service teachers mentioned that clinical experiences including onsite observations and guidance from and reflection with mentor teachers were the most beneficial components of their teacher learning experience (Andrew & Schwab, 1995; Delaney, 1995). Additional evaluation studies found that pre-service teachers needed more coursework in classroom management skills, more training time for improving communication with parents, and emphases on the diverse needs of our students socially or academically (Darling-Hammond, Chung, & Frelow, 2002; Whitney et al., 2002). Darling-Hammond (2003) also wrote about how a survey instrument in the teacher education program played a role in identifying areas for improvement:

> An analysis … helped us to understand how specific aspects of the program were working for these students. Discovering how much they

> valued certain kinds of learning opportunities encouraged us to maintain and expand certain components as we consider annual program changes. It has also clarified our thinking about how to educate already experienced teachers in a pre-service program. (pg. 17)

One research study (Latterell, 2008) offered a snapshot of ten pre-service teachers by conducting a survey instrument, interview, and two mathematics tests. Latterell (2008) calls for more replication studies with larger groups of pre-service teachers at various certification levels as well as with the pre-service teachers who actually learned mathematics with NCTM-oriented curricula when they were K-12 students. Furthermore, the NCATE Assessments Example Project collected examples of assessments submitted by teacher educators and reported that while responding to NCATE's focus on using assessment results as evidence that pre-service teachers have mastered state and national standards, teacher education program evaluations have tried to build on actual examples of how other teacher preparation programs implemented an alignment of assessments with standards (Elliott, 2003). Elliot (2003) adds that such examples can serve to illustrate what is possible and provide a foundation for new ideas and that teacher education program evaluations can benefit not so much from a robust experimental design from external experts on testing and test development; instead, what is needed is sharing experiences and insights among colleagues in other teacher education programs as to developing systematic evaluation for program improvement. Still, Cochran-Smith (2001) argues that evidence alone in an evaluation does not necessarily inform teacher educators on what to do. She asserts that evidence needs to be interpreted, and that creating a culture of both evidence and inquiry in teacher education has the potential to build the capacity within teacher education programs to assess progress and effectiveness and gain knowledge to bring about a real change.

Summary

There has been an extensive research base for NCTM-Standards-based reform in mathematics education. Literature about what constitutes standards-based mathematics instruction as well as teacher knowledge, such as pedagogical contents knowledge (PCK) offers a basis for national and state standards, which in turn informs mathematics teacher preparation programs. What can pre-service teachers learn during their preparation programs to become effective mathematics teachers? It is difficult to imagine preparing future mathematics teachers without a systematic approach aligned with state and national standards, which indeed provides a guide for identifying knowledge and experience necessary for pre-service teachers to have and in turn provide the same for our students. Such systematic approach merits data-driven evaluation. The current condition of teacher education program evaluation efforts is to use multiple measures and gather data about pre-service teachers' performance in relation to the various outcomes of teacher educations. Indeed, literature about innovative teacher education programs as well as systematic evaluations supports the efforts of teacher educators to specify the learning outcomes, examine its alignment with state and national standards, and analyze the evidence of learning to improve programs.

Recent research about measures on mathematics teacher knowledge and examples of teacher education programs that used their pre-service teachers' pedagogical capacity as an integral part of evaluation inform evaluating a teacher education program using a

PCK assessment. Assessing pre-service teachers' PCK might offer an insight into the current state of pre-service teachers' knowledge about mathematics and its teaching. Building on the current literature, this study posited that assessing pre-service teachers' PCK might offer an insight into the current state of pre-service teachers' knowledge about mathematics and its teaching. Furthermore, survey responses reflecting pre-service teachers' voice contributed to understanding of how the pre-service teachers perceive their learning in the program. As a result of accumulating a knowledge base for a systematic evaluation of the mathematics education component of a teacher certification program, the study could serve as a reference point for future studies about teacher education evaluations. The next section provides the methodology of this study including research design, participants, data collection procedures/instruments, and data analysis and limitations of the study.

CHAPTER THREE

Methodology

This study was an evaluation of the 4-8 mathematics component of a teacher preparation program at an urban research university, the University of Houston. The research questions were: (1) To what extent is the 4-8 mathematics teacher preparation program consistent with state standards for mathematics teacher preparation? (2) What content and pedagogical content knowledge can 4-8 mathematics pre-service teachers demonstrate at their respective points in the program? (3) What are the pre-service teachers' perceptions of preparedness for teaching mathematics? This chapter begins with a description of the research site and the teacher preparation program. It then describes an overview of how the study answered the research questions, followed by information about participants, data collection, and instruments. Lastly, it describes data analysis methodologies and study limitations.

Research Site and the Program

The research site, the University of Houston, is an urban public research university located in Houston, TX, a diverse metropolitan city. The University serves a socioeconomically diverse student population. The student body comprises more than 36,000 undergraduate and graduate students representing more than 137 nations. It is a large research institution offering doctoral and professional degree programs.

The teacher education program of the study is a comprehensive teacher preparation program at the University that prepares teachers for urban public school teaching. There are seven certification options: EC-6 Generalist, Bilingual Generalist, Special Education, and 4-8 English/Language Arts and Reading, Mathematics, Science, and Social Studies. QUEST (Quality Urban Education for Students and Teachers) offers a BS degree in Interdisciplinary Studies with certification, an M.Ed in Secondary Education with certification, or Non-degree objective status with certification. More than 200 pre-service teachers enroll in the program each year.

The QUEST program is a state approved teacher education program. The College of Education at the University is accredited by the National Council for accreditation of Teacher Education (NCATE). NCATE is recognized by the U.S. Department of Education and the Council for Higher Education Accreditation to accredit programs for the preparation of teachers. The Texas Examinations of Educator Standards (TExES) assessment is required in the state of Texas as part of the teacher certification process. Pre-service teachers receive approval to take the official TExES examination from the Office of Student Services in the College of Education at the University.

QUEST has three main components. QUEST 1 focuses on introducing teaching as a career. Coursework and field experiences are designed to have teacher candidates interact with children in public schools and gain knowledge in the discipline area and general education theories. QUEST 2 focuses on skills and knowledge of teaching specific to the discipline (English/Language Arts and Reading, Mathematics, Science, and Social Studies). The pre-service teachers learn current methods for teaching and participate in practice teaching in school settings. Additionally, the pre-service teachers in QUEST 2 are expected to have successfully completed all benchmarks that are listed on the individual degree or certification plans by the end of QUEST 1. The benchmarks include completion of all four Diagnostic Mathematics Assessments for Middle School

Teachers (DTAMS) assessments, successful completion of courses in QUEST 1, successful completion of university core courses, positive recommendations, passing of TExES Pedagogy and Professional Responsibilities Benchmark Test, and a minimum 2.50 GPA in coursework. QUEST 3, is the student teaching semester where pre-service teachers gain experience in the work of teaching partnered with classroom teachers in the neighboring schools. Student teaching at the University is a 14-week, all-day experience with a practicing teacher. Pre-service teachers also participate in student teaching professional development sessions on campus at the University and receive online guidance from faculty and peers. The program administration includes advisors, certification analysts, program assistants, the director of student teaching, the department chair, the director of teacher education, and the mathematics education program area coordinator.

The 4-8 mathematics teacher preparation coursework included nine courses for learning the content and pedagogy specific to teaching middle school mathematics. Coursework in QUEST 1 for 4 – 8 mathematics certification consists of six mathematics courses and one mathematics education course. This coursework typically spans two semesters with 20 hours of field experiences per semester that consists of observations in middle school mathematics classrooms. The mathematics courses provided a broad range of mathematical topics from algebra, probability, statistics, problem solving to more advanced topics, such as number theory, analysis, and analytical geometry. The mathematics education course provided pedagogical preparations for teaching middle school mathematics. Coursework in QUEST 2 includes two mathematics education courses in which pedagogical issues relating algebra, geometry, and proportional reasoning are discussed. 40 hours of field experiences that include small practice-teaching opportunities in middle school mathematics classrooms are embedded in this coursework.

Research Design

This is a descriptive study that used existing course syllabi, paper/pencil assessments, and an anonymous web-based survey to provide descriptions of the university's 4 – 8 mathematics certification program and of knowledge and perceptions of pre-service teachers seeking 4 – 8 mathematics certification in Texas. This study sought to answer (1) To what extent is the 4-8 math QUEST program consistent with state standards? (2) What content and pedagogical content knowledge can QUEST students demonstrate at their respective points in the program? (3) What are the pre-service teachers' perceptions of preparedness for teaching mathematics?

The first research question was addressed by conducting a document analysis of course syllabi and learning resources available through program and course websites. Mainly, the TExES matrix, described below, was used to examine how well the courses in the program align with the state standards and to find evidence of how the learning outcomes of the TExES Standards are reported to be addressed within coursework. A paper/pencil assessment called Diagnostic Mathematics Assessments for Middle School Teachers (DTAMS) was used to answer the second research question. Descriptive statistics were used to report content and pedagogical knowledge level of pre-service teachers. The study sampled how pre-service teachers responded to some test items in order to complement the statistical analysis. The third research question was addressed by examining students' written responses from an anonymous web-based survey. The survey instrument, described below, allowed respondents to provide perceptions of their preparedness for teaching mathematics and the levels of their satisfaction with the program components as well as their recommendations for improvements.

Research Instruments

The primary research tools included a TExES matrix, DTAMS, and the QUEST Anonymous Survey. Each instrument is described below.

TExES matrix. The State Board for Educator Certification (SBEC) has approved Texas educator standards that delineated what the beginning teacher should know and do. These standards formed the basis for the TExES program. The TExES matrix was constructed by using the standards specific to grades 4 – 8 mathematics certification including learning outcomes. The matrix can be found in Appendix A. Then, grouping of the learning outcomes was made according to whether it was a learning outcome that would be addressed in a mathematics course or a mathematics education course. Table 1 shows an example of learning outcomes categorized into two groups. There were 35 number of overlapping learning outcomes between mathematics courses and mathematics education courses because some content areas, such as geometry and proportional reasoning are part of curriculum in both mathematics courses and mathematics education courses.

Table 1
Examples of Learning Outcomes Used

Standards (Learning Outcomes)	Example	*N*
Mathematics	To understand the relative magnitude of whole numbers, integers, rational numbers, and real numbers.	81
Mathematics Education	To understand how to evaluate a variety of assessment methods and materials for reliability, validity, absence of bias, clarity of language, and appropriateness of mathematical level.	71
Total		152

DTAMS. DTAMS are assessments for middle grade mathematics teachers that were developed at the Center for Research in Mathematics and Science Teacher Development (CRMSTD) at the University of Louisville. The assessments measure mathematics and mathematics pedagogy knowledge in four content domains (Number/Computation, Geometry/Measurement, Probability/Statistics, and Algebraic Ideas). The assessments are scored by CRMSTD staff, and a spreadsheet of scores by knowledge type (Type I – memorized/factual knowledge; Type II – conceptual understanding; Type III – reasoning/problem solving; Type IV – pedagogical content knowledge) for each teacher is provided. The items posed in DTAMS were developed by mathematicians, mathematics educators, and teachers for the purpose of gathering information about the participant’s content knowledge and PCK. Questions are developed addressing memorized knowledge, conceptual understanding, problem solving/reasoning, and pedagogical content knowledge. Memorized knowledge includes the knowledge of definitions, procedures, or rules. Conceptual understanding includes an understanding of mathematical properties and concepts and knowledge of connections and relationships among concepts. Problem solving/reasoning examines teachers' mathematical thinking, reasoning, and capacity for problem solving. In addition, the teachers' capacity to conjecture, analyze, validate, and justify mathematical ideas is assessed. Pedagogical content knowledge represents the mathematics knowledge that teachers use in the act of teaching. It includes knowledge of selecting the most appropriate forms of representation of mathematical ideas for students as supported by standards-based curricula. Teachers with this knowledge can identify student misconceptions about mathematics, provide appropriate feedback to correct them, and use the opportunity to generate meaning mathematical discourse with the students.

The validity of the assessments is ensured according to the test creators; the test items were developed by teams of mathematicians, mathematics educators, and middle school teachers that used national standards and recommendations and research on misconceptions for both middle school students and teachers. After the development stage, national reviewers assessed the appropriateness of items. Reliability is established from the results of pilot investigations performed by the developers and reported as follows: Internal reliability was determined by obtaining Cronbach's alpha far exceeding the acceptable measure of 0.7 for internal consistency (Allen & Yen, 2002). Inter-scorer reliability was also established using percents of agreements among three graduate students who developed and used the scoring guides for scoring open-response items. One recent study (Saderholm, Ronau, Brown, & Collins, 2010) adds, "The DTAMS constitutes a reliable, valid assessment that will inform middle-school teachers about their mathematical strengths and areas in which they can improve" (p. 190). Saderholm et al.

(2010) further argued that pre-service teachers who scored 50% on DTAMS knew about 50% of the content necessary to teach middle school mathematics, and that only 17% of teachers in their study scored higher than about 70% on all tests across content subcategories.

QUEST anonymous survey. This survey was web-based and designed to allow pre-service teachers to indicate their perceptions of preparedness for teaching mathematics as well as the level of satisfaction for coursework of the QUEST program. The survey can be found in Appendix B. The survey consisted of questions or statements, as provided below, to which pre-service teachers responded by checking a rating corresponding to degree of their agreement.

- Preparedness
    - How well do you feel that your program prepared you (or is preparing you) for the following TExES standards?
    - How well did your program prepare you for the following five processes of standards of the National Council of Teacher of Mathematics?
    - The program provided me opportunities to build an adequate foundation in mathematics necessary to be an effective mathematics teacher.
    - The program provided me opportunities to build an adequate foundation in the teaching knowledge necessary to become an effective mathematics teacher.
- Satisfaction
    - How satisfied are you about the mathematics education courses?
    - How satisfied are you about the general mathematics courses?
    - How satisfied are you about the field experiences of the QUEST program?
    - How satisfied are you about the overall program coursework in the 4 – 8 mathematics teacher preparation program?

In addition, the survey allowed participants to provide additional written responses with the inclusion of a commentary box for each survey item and the prompt, “Please elaborate more specifically if necessary.” These responses were used to elicit clarification. Participants were also asked the following questions to elicit more specific responses when it came to the QUEST coursework:

- Which mathematics education courses do you think were important (or unimportant) in your preparation to be a math teacher?
- Which mathematics courses do you think were important (or unimportant) in your preparation to be a math teacher?

At the end of the survey, pre-service teachers were asked to provide their recommendations with a written response to the following question: “What would you change about the program to improve the mathematics education component of QUEST, such as course sequencing, program requirements, teaching practices, etc.?”

Participants and Participant Selection

Included in the study are 4-8 mathematics certification students who were/are enrolled in QUEST 1, QUEST 2, and QUEST 3 courses Fall 2010 – Spring 2011. Expected maximum number of participants was forty, who were informed about the general nature of the study by the director of the QUEST program and the mathematics educator program coordinator. Twenty nine pre-service teachers participated and completed DATMS testing. Twenty three pre-service teachers participated in QUEST anonymous survey. As a part of mathematics education program requirements, all incoming QUEST 2 students are required to take the DTAMS. The QUEST anonymous web-based survey is optional. All 4 – 8 mathematics QUEST students who completed at least one DTAMS assessment or responded to the web-based survey were included in this evaluation. Regarding the DTAMS and survey overlap – the study asked the participants to provide their 4-digit code on the survey - that would be the only indication that they have completed both DTAMS and the survey. Because the survey was anonymous, the number of participants who took the survey and DTAMS is unknown.

Data Collection

DTAMS. The department of Curriculum and Instruction administered all four DTAMS, one for each content area (Number Computation, Geometry/Measurement, Probability/Statistics, and Algebraic Ideas) in fall, 2010 and spring, 2011, as part of normal program evaluation efforts. When pre-service teachers completed these assessments, they constructed a four-digit code, known only to themselves, to use on all four assessments. Participants were asked to input the same four-digit code when they completed the anonymous survey. Each assessment consisted of 20 items that were 10 multiple-choice and 10 open-response items. The average length of time to take the assessments was 75 minutes, although pre-service teachers were permitted to take as long as they needed. Administration of the DTAMS followed the protocol provided by the developers of the instrument, including permitting the per-service teachers to use graphing calculators. The assessments were scored by CRMSTD staff only, and a spreadsheet of scores for each teacher was provided. No names were provided in the spreadsheet. Only the participant-constructed 4-digit codes were provided in the spreadsheet.

QUEST anonymous survey. To assess pre-service teachers' perceptions of their preparedness for teaching as well as their ideas to improve the quality of the QUEST program, the director of QUEST administered one web–based constructed response survey. A link to an anonymous web-based survey was distributed through the QUEST email listserv. The survey was available for twenty five business days.

TExES matrix. The study first looked for evidence to what extent the 4 – 8 mathematics certification coursework addressed the TExES standards. The QUEST degree plan was obtained from the mathematics education program area coordinator. The degree plan is also publicly available through the QUEST website. This allowed the researchers to identify the specific mathematics and mathematics education courses for the 4- 8 mathematics certification program. Mathematics instructors in the Department of Mathematics directed the mathematics education program coordinator and researcher to the publicly open mathematics course websites; syllabi and learning resources were retrieved from these websites. The syllabi for mathematics education courses are submitted to the mathematics education program coordinator and to the department each semester. Syllabi were collected by the mathematics education program coordinator and sent to the researcher for analysis. The QUEST program and the mathematics education program area websites were also available for analysis. Using the TExES matrix, the researcher then checked whether a learning outcome was addressed in syllabi and/or course documents.

About the Researcher

The researcher has 9 years of teaching experience in mathematics. He holds a masters degree in mathematics as well as secondary math (6 – 12) certification.

Data Analyses

Syllabi analysis. 152 learning outcomes were used as parameters to check whether mathematics and mathematics education courses adequately covered the TExES

Standards. The learning outcomes were categorized into two groups: mathematics and mathematics education. 35 overlapping learning outcomes were expected to be covered both in mathematics and mathematics education courses.

Table 2

Example of Process of Decision Making on Alignment

	TExES	Decision on alignment
Standard	The teacher understands ideas of number theory and uses numbers to model and solve problems within and outside of mathematics.	
Learning Outcome	The beginning teacher applies knowledge of place value and other number properties to develop techniques of mental mathematics and computations estimation.	(1) Covered on application of the knowledge (2) Unknown about developing techniques of mental math and computations estimation.
	Evidence	
Syllabus	"Lesson topic: place value and number bases"	Initial evidence
Learning resource (worksheet)	"Determine the value of the 3 in $634_{(7)}$."	Second evidence as validation
Instructor feedback	"We teach that." "They should know how to do those."	Additional evidence
Final decision on alignment		Covered

When learning outcomes were too ambiguous to decide whether the mathematics courses addressed them, the researcher asked instructors. After the coverage of learning outcomes was determined by researcher, the result was sent to instructors for review. When an instructor thought a particular learning outcome was actually covered but the study's analysis indicated as uncovered, researcher took feedback from instructors into consideration but made a final decision independently regarding coverage. Table 2 illustrates an example of the extent the study was able to investigate an alignment of standards, a decision making regarding alignment, and its limitation.

Analysis of DTAMS data. The DTAMS were scored by the Center for Research in Mathematics and Science Teacher Development (CRMSTD) at the University of Louisville, and a spreadsheet of scores for each teacher was provided. Descriptive statistics including tables of average scores, quartiles, and standard deviations were used to represent the data of pre-service teachers' current professional knowledge on mathematics and its teaching.

The DTAMS Math Scoring Summary provided test results for all pre-service teachers, including aggregate scores and group averages grouped by the four assessments categories (Number Computation, Probability/Statistics, Geometry/Measurement, and Algebraic Ideas). For each assessment, the subcategories include knowledge type (Type I–memorized/factual knowledge, Type II–conceptual understanding, Type III–reasoning/problem solving, and Type IV–pedagogical content knowledge) as well as the specific content areas shown in Table 3.

Table 3
Content Subcategories for each Assessment

Number Computation	Probability & Statistics	Geometry & Measurement	Algebraic Ideas
Whole Numbers Rational Numbers Integers Number Theory & Number Systems	Statistics Probability	Two-Dimensional Geometry Three-Dimensional Geometry Transformational Geometry Measurement	Patterns, Functions, and Relations Expressions and Formulas Equations and Inequalities

Analysis of QUEST anonymous survey. The analysis of the pre-service teachers' perceptions of preparedness and their recommendations drew on data from the survey. Mostly due to the direct expressions the pre-service teachers used, their written responses were not coded in a standardized way in order to interpret hidden meanings. For example, when a respondent wrote, "It will be perfect if the class became smaller, therefore [we] get more time to learn" a theme of "smaller class size" was chosen for categorization. When a respondent wrote, "I want classes that give me more life tips on how to teach kids math, not only teaching in general, but specifically teaching math" a theme of "an emphasis in the teaching knowledge" was used. However, student comments that did not have a clear meaning, and therefore were open to inconsistent interpretations, were not used. For example, "probability and stat geometry connections reasoning" and "all of them" exemplify unused data because neither comment specified whether the mentioned content is important or unimportant.

Limitations

The population of interest is drawn from a single university; the findings may not generalize to other universities because of this narrow focus. The generalization and application of the results may require a setting similar to that of the study. In fact, the study notes that this research study is an evaluative study for one component of a particular teacher education program and is done in part to get a sense of what the program is doing well and how to improve further. In other words, the study is not meant to generalize the findings beyond the extent of the mathematics education component of QUEST program at the University.

A second limitation of the study is that the content of QUEST courses was inferred directly from the publicly available syllabi and websites. It is feasible that the implemented curriculum is different than the intended curriculum. Classroom observations and interviews with instructors may have strengthened the validity of the findings; however, these strategies were not feasible at the time of the study. The researcher did participate in informal conversations with mathematics and mathematics education instructors regarding their courses but did not formally interview the instructors.

A third limitation of the study is that the mathematics education QUEST pre-service teachers were not interviewed regarding their responses on the QUEST anonymous survey. This was purposeful in that the intention was to keep the responses anonymous. However, the reader should remain aware that survey choices and comments were taken at face value without further input from the participants.

CHAPTER FOUR

Results

As part of ongoing efforts to evaluate teacher education programs, the purpose of this study was to provide a springboard for future research within the 4 – 8 mathematics teacher preparation program at the University of Houston by assessing the following: (1) course alignment with state standards, (2) pre-service teacher knowledge at their respective stages of the program, and (3) pre-service teachers' perceptions of their preparedness for teaching middle school mathematics. This chapter presents the results related to the following three research questions:

Research Question One. To what extent is the 4-8 mathematics teacher preparation program consistent with state standards for mathematics teacher preparation?

Research Question Two. What content and pedagogical content knowledge can 4-8 mathematics pre-service teachers demonstrate at their respective points in the program?

Research Question Three. What are the pre-service teachers' perceptions of preparedness for teaching mathematics?

Research Question One

The results regarding question one as it relates to the mathematics courses are shared first, followed by results regarding the mathematics education courses. The first six mathematics courses are offered by the Mathematics Department and the three mathematics education courses are offered by the Department of Curriculum and Instruction.

Mathematics courses. Based on a review of course documents, the methods of instruction and course format included lecture, discussion, and demonstrations. Student grades were based on assessments of participation, homework, and exams/tests/quizzes. Learning materials included textbooks, PowerPoint slides, calculators, and worksheets. A mathematics course syllabus was typically two pages in length. The information in a typical mathematics course syllabus provided a brief course description, contact information, office hours, required course materials, grading methodology, and a list of administrative policies and rules. One syllabus provided the following general course description that was titled, "Learning Objectives" as shown below.

> "A student who completes this course should be proficient in the following topics: a short history of written numerals, systems of measurement, the real number field and its properties, basic number theory of primes, divisors and multiples, expressions and equations, the definition of a function, linear and quadratic functions and an introduction to abstract algebraic systems."

The brevity was typical. With a review of the syllabi as well as learning resources found on websites, the study could report whether standards were met but could not ascertain alignment to some learning outcomes (1) because of the brevity of the syllabi and (2) because the researcher did not observe the instruction nor interview the instructors. About 17% of mathematics learning outcomes (14 out of 81) from the TExES matrix were not addressed. The following table shows the actual learning outcomes found not being addressed in the mathematics courses.

Table 4

Learning Outcomes of the TExES Standards Not Addressed in the Mathematics Courses

Learning Outcomes Not Addressed
To analyze and describe relationships between number properties, operations, and algorithms for the four basic operations involving integers, rational numbers, and real numbers.
To use a variety of concrete and visual representations to demonstrate the connections between operations and algorithms.
To justify procedures used in algorithms for the four basic operations with integers, rational numbers, and real numbers, and analyzes error patterns that may occur in their application.
To demonstrate an understanding of ideas from number theory (e.g., prime factorization, greatest common divisor) as they apply to whole numbers, integers, and rational numbers, and uses these ideas in problem situations.
To apply knowledge of place value and other number properties to develop techniques of mental mathematics and computational estimation.
To use inductive reasoning to identify, extend, and create patterns using concrete models, figures, numbers, and algebraic expressions.
To make, test, validate, and use conjectures about patterns and relationships in data presented in tables, sequences, or graphs.
To gives appropriate justification of the manipulation of algebraic expressions.
To use linear functions, inequalities, and systems to model problems.
To describe the precision of measurement and the effects of error on measurement.
To demonstrate an understanding of the characteristics of linear models and the advantages and disadvantages of using a linear model in a given situation.
To analyze data and represents and solves problems involving exponential growth and decay.
To apply properties, graphs, and applications of nonlinear functions to analyze, model, and solve problems.
To analyze the relationship among three-dimensional figures and related two-dimensional representations (e.g., projections, cross-sections, nets) and use these representations to solve problems.

Overall, mathematics courses nearly met standards since the study found evidence to conclude that the courses covered about 83% of the mathematics learning outcomes drawn from the TExES Standards.

Mathematics education courses. A review of mathematics education course syllabi indicated that the instructors of mathematics education courses provided course objectives that adhered to state or national standards. All syllabi contained detailed information about the conceptual framework that conveyed the instructors' teaching approach and student learning outcomes aligned with state and national standards, such as the TEKS, TExES, and NCATE/NCTM. In addition to administrative rules and policies, the information in a typical syllabus was a comprehensive presentation of a learning system that promoted pedagogies, participation, and activities that have direct ties to learning outcomes guided by state and national standards. Additionally, the syllabi supported a common goal of providing an educational experience based on research and professional standards. Student grades were determined using multiple assessments; all courses offered more than five different ways of evaluating student performance. Also noticeable was that these assessments were aligned with the standards. Table 5 is part of a syllabus that exemplifies how specific learning outcomes are measured in a variety of methods.

Based on course syllabi, the study found that mathematics education courses covered all 71 mathematics education learning outcomes drawn from the TExES Standards. Evidence of alignment between the standards and the course assessments was also found.

Table 5
Sample Content of Syllabus

Course Goals & Objectives: Students will

What	How – Through …	Assessment
Develop and strengthen proportional reasoning skills and concepts	Small group in-class problem-solving activities and Mathematics hw sets.	Presentations of mathematical thinking; Performance on hw sets; Midterm exam; Final exam.
Identify and assess key components of proportional reasoning and development	Assigned readings; Self-selected readings; Class activities. Task-based interviews.	Concept Map; Reflections/analysis of interviews; Midterm exam; Final exam;
Identify where proportional reasoning concepts are used/developed across the K-12 mathematics curriculum	Assigned readings; Self-selected readings; TEKS analysis; TAKS analysis; TExES analysis.	Discussions about readings; Appropriate analysis of items; Midterm exam; Final exam.
Describe and apply research-based recommendations about how children develop proportional reasoning skills and concepts and the corresponding instructional practices that facilitate this development	Assigned readings; Self-selected readings; Task-based interviews; Lesson design & implementation.	Discussions about readings; Reflections/analysis of interviews; Feedback to peers regarding lessons; Appropriate lesson design & reflections; Midterm exam; Final exam.

Research Question Two

The second research question asked what content and pedagogical content knowledge can 4 – 8 mathematics pre-service teachers demonstrate at their respective points in the program.

Overall Performance

Table 6 shows average group scores for each assessment performed by pre-service teachers in QUEST 1 and QUEST 2. Pre-service teachers in QUEST 1 and QUEST 2 displayed the strongest knowledge in Number Computation, followed by Algebraic Ideas, Geometry/Measurement, and Probability/Statistics. However, the pre-service teachers' overall content knowledge is not strong with average scores lower than 60%. The two lowest-performing content knowledge areas were Geometry/Measurement and Probability/Statistics. Pre-service teachers in QUEST 1 performed better than QUEST 2 as a group.

Table 6
DTAMS Group Average Scores by Content Areas

Subcategory	QUEST 1 (N=11) Average Score	QUEST 2 (N=18) Average Score
Number Computation	57%	51%
Probability & Statistics	33%	25%
Geometry & Measurement	40%	34%
Algebraic Ideas	43%	40%

Table 7 shows the percentile average scores. The 25th and 75th quartile scores were computed to show the range of average scores for the middle 50% of pre-service teachers for each content area. For example, the middle 50% of the pre-service teachers in QUEST 1 correctly answered the questions about Number Computation between 48% and 66% of the test, but the same group scored between 28% and 36% in the area of

Probability and Statistics. In this way, the data can provide a more representative picture of the QUEST group scores without the effect of outliers.

Table 7
Percentile Average Scores by Content Areas

Content Area	QUEST 1		QUEST 2	
	25th percentile	75th percentile	25th percentile	75th percentile
Number Computation	48%	66%	34%	53%
Geometry & Measurement	31%	44%	23%	45%
Probability & Statistics	28%	36%	15%	40%
Algebraic Ideas	35%	44%	24%	50%

Table 8 shows group average scores by knowledge type. Pre-service teachers in both QUEST 1 and QUEST 2 displayed the highest scores for Memorized/Factual Knowledge, followed by Conceptual Understanding, Reasoning/Problem Solving, and Pedagogical Content Knowledge.

Table 8
Group Average Scores by Knowledge Types

Subcategory	QUEST 1 (N=11) Average Score	QUEST 2 (N=18) Average Score
Memorized & Factual Knowledge	57%	50%
Conceptual Understanding	51%	44%
Reasoning & Problem Solving	33%	30%
Pedagogical Content Knowledge	23%	25%

Performance by Content Areas

Number Computation. Table 9 shows the average scores as well as standard deviations for Number Computation, organized by knowledge type and QUEST program level. The table shows that pre-service teachers have relatively higher Memorized/Factual

Knowledge than Reasoning/Problem Solving or Pedagogical Content Knowledge in Number Computation. In addition, the larger standard deviation for pedagogical content knowledge scores by QUEST 1 pre-service teachers indicates a great amount of variability of pedagogical content knowledge. On the other hand, the smaller standard deviation for Memorized/Factual knowledge scores by the same group indicates a less variability in the scores. For QUEST 2 pre-service teachers, the variability was the same for Memorized/Factual Knowledge and Pedagogical Content Knowledge.

Table 9
Group Average Scores in Number Computation by Knowledge Types

	QUEST 1 (N=11)		QUEST 2 (N=18)	
Knowledge Type	M	SD	M	SD
Memorized & Factual Knowledge	66%	18	61%	18
Conceptual Understanding	60%	26	50%	23
Reasoning & Problem Solving	45%	26	44%	25
Pedagogical Content Knowledge	52%	29	41%	18

Table 10 breaks down pre-service teachers' average scores according to the content subcategories. For example, QUEST pre-service teachers have relatively more knowledge of Whole Numbers but less knowledge in the areas of Number Theory and Number Systems.

Table 10
Group Average Scores in Number Computation by Topics

Subcategory	QUEST 1 (N=11) Average Score	QUEST 2 (N=18) Average Score
Whole Numbers	67%	64%
Rational Numbers	57%	40%
Integers	54%	48%
Number Theory & Number Systems	41%	33%

Probability and Statistics. Table 11 shows the average scores and standard deviations for the Probability/Statistics content area by knowledge type. Table 12 shows how pre-service teachers performed in each topic (Probability and Statistics) as a group. Almost every pre-service teacher in QUEST 2 has very low pedagogical content knowledge in Probability and Statistics, as indicated by an extremely low average (8%) coupled with a very low standard deviation (10). Moreover, QUEST 2 performed more poorly than QUEST 1 in Probability/Statistics. The scores measuring pedagogical content knowledge in Probability and Statistics were much lower than the scores for other knowledge types. Table 12 shows that pre-service teachers did not display much difference in their Probability and Statistics knowledge level. That is, pre-service teachers struggled with both Probability and Statistics relatively the same amount.

Table 11
Group Average Scores in Probability and Statistics by Knowledge Types

	QUEST 1 (N=11)		QUEST 2 (N=18)	
Knowledge Type	M	SD	M	SD
Memorized & Factual Knowledge	51%	16	42%	18
Conceptual Understanding	48%	22	37%	23
Reasoning & Problem Solving	21%	25	18%	21
Pedagogical Content Knowledge	12%	15	8%	10

Table 12
Group Average Scores by Topics

	QUEST 1 (N=11)	QUEST 2 (N=18)
Subcategory	Average Score	Average Score
Statistics	33%	28%
Probability	34%	27%

Geometry and Measurement. Table 13 shows the average scores and standard deviations in the area of Geometry and Measurement for each knowledge type. Table 14 shows how pre-service teachers performed in each topic (Two-Dimensional Geometry, Three-Dimensional Geometry, Transformational Geometry, and Measurement). On average, the QUEST 1 group has better content knowledge in Measurement than the other topics, and the QUEST 2 group has better content knowledge in Transformational Geometry than other topics.

Table 13
Group Average Scores in Geometry and Measurement by Knowledge Types

Knowledge Type	QUEST 1 (N=11)		QUEST 2 (N=18)	
	M	SD	M	SD
Memorized & Factual Knowledge	60%	21	51%	29
Conceptual Understanding	42%	18	42%	16
Reasoning & Problem Solving	33%	28	24%	20
Pedagogical Content Knowledge	27%	22	22%	14

Table 14
Group Average Scores by Topics

Subcategory	QUEST 1 (N=11) Average Score	QUEST 2 (N=18) Average Score
Two-Dimensional Geometry	35%	27%
Three-Dimensional Geometry	35%	34%
Transformational Geometry	44%	48%
Measurement	48%	31%

Algebraic Ideas. Table 15 shows the average scores and standard deviations for Algebraic Ideas organized by knowledge type. Table 16 shows how pre-service teachers performed in each topic (Patterns, Functions, and Relations, Expressions and Formulas, and Equations and Inequalities). On average, pre-service teachers have better knowledge of Equations/Inequalities than other subcategories of Algebraic Ideas.

Table 15
Group Average Scores in Algebraic Ideas by Knowledge Types

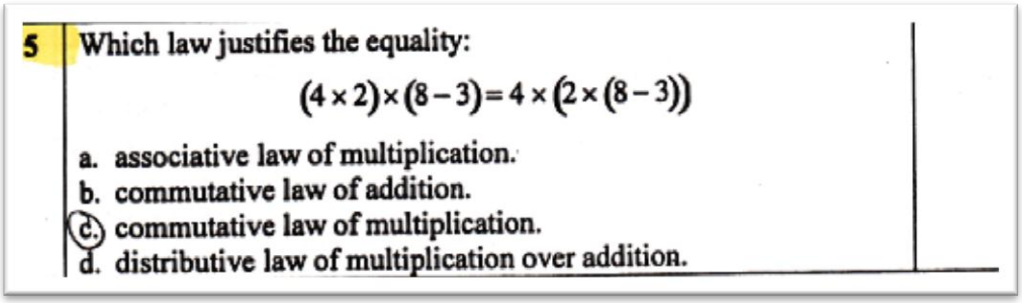
Knowledge Type	QUEST 1 (N=11) M	QUEST 1 (N=11) SD	QUEST 2 (N=18) M	QUEST 2 (N=18) SD
Memorized & Factual Knowledge	52%	22	45%	22
Conceptual Understanding	52%	12	48%	19
Reasoning & Problem Solving	31%	18	33%	24
Pedagogical Content Knowledge	31%	14	29%	15

Table 16
Group Average Scores by Topics

Subcategory	QUEST 1 (N=11) Average Score	QUEST 2 (N=18) Average Score
Patterns, Functions, and Relations	36%	37%
Expressions and Formulas	41%	36%
Equations and Inequalities	55%	42%

A closer look at student work in DTAMS. In order to illustrate how pre-service teachers typically answered DTAMS questions, one test per assessment was randomly chosen for analysis. Then, one question that had the lowest group score was selected. In Number Computation, for example, only six out of 18 pre-service teachers answered item 5 correctly. The item assesses pre-service teachers' understanding of the three basic number properties that apply to arithmetic operations. The question relates to a TExES learning outcome, "To analyze and describe relationships between number properties, operations, and algorithms for the four basic operations involving integers, rational numbers, and real numbers." Basic number properties are important in advanced mathematics and considered as a significant foundation for understanding number systems. Students typically memorize the rule in a form known in the following form, "$(a \cdot b) \cdot c = a \cdot (b \cdot c)$." In the test item, the equation looks different from the standard form, yet it is displaying the same rule because the substitution is done in the following way: $a = 4; b = 2; c = (8 - 3)$. When pre-service teachers do not have the opportunity to explore and analyze the number properties, they may struggle with this type of question.

Figure 1
Item 5 on Number Computation



5 Which law justifies the equality:

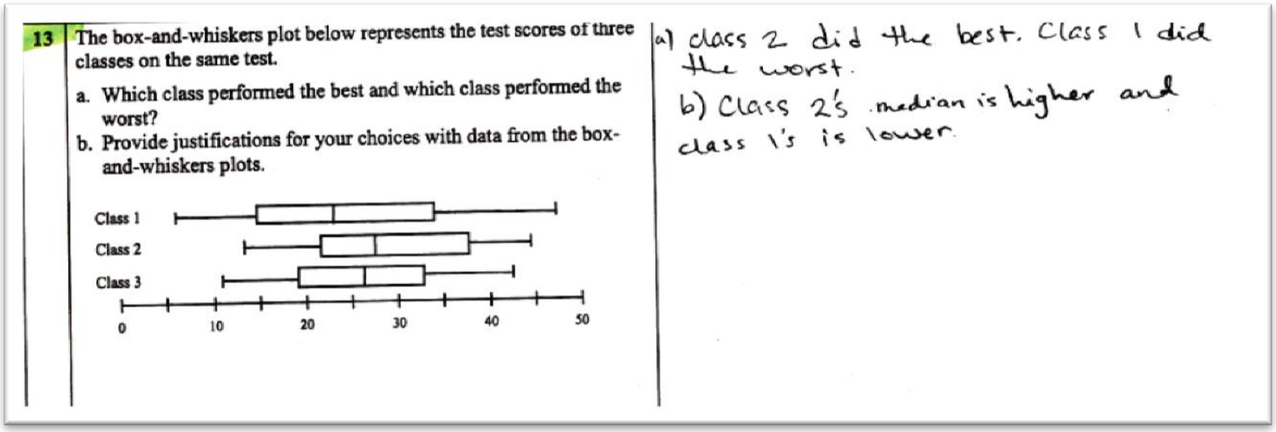
$$(4 \times 2) \times (8 - 3) = 4 \times (2 \times (8 - 3))$$

a. associative law of multiplication.
b. commutative law of addition.
c. commutative law of multiplication.
d. distributive law of multiplication over addition.

In Probability/Statistics, only two pre-service teachers out of 18 answered item13 correctly. The item asks about pre-service teachers' understanding of visual representations of data, including the center, spread, and range of a distribution and conclusions about group differences. The question relates to a learning outcome, such as, "To support arguments, make predictions, and draw conclusions using summary statistics and graphs (e.g., tables, frequency distributions, stem-and-leaf plots, box-and-whisker plots, histograms, pie charts) to analyze and interpret data." In the example below, the pre-service teacher response is incomplete since a definition of the best performance was not presented and the response did not discuss the distribution's spread, quartiles or range.

Figure 2

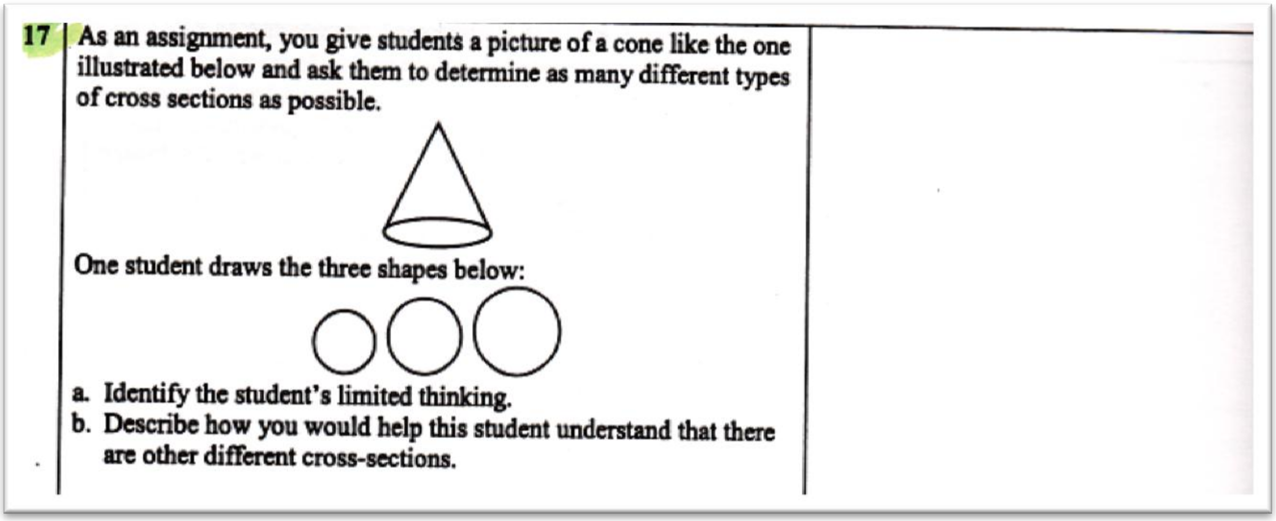
Item 13 on Probability/Statistics



In Geometry/Measurement, only two pre-service teachers out of 18 answered item 17 correctly. The item assesses pre-service teachers' understanding of the relationship between 2-dimensional space and 3-dimensional space as well as their pedagogical capacity to identify student misunderstanding and to design appropriate learning activities addressing this gap. The question relates to the following TExES learning outcomes: "To analyze the relationship among three-dimensional figures and related two-dimensional representations (e.g., projections, cross-sections, nets) and use these representations to solve problems" and "To understand the relationship between assessment and instruction and know how to evaluate assessment results to design, monitor, and modify instruction to improve mathematical learning for all students." Most QUEST 1 pre-service teachers did not provide a response. Some QUEST 2 pre-service teachers attempted the question but had a difficulty describing the students' thinking and coming up with other possible figures of the cross sections. These results indicate that pre-service teachers might benefit from participating in explorations and hands-on activities to develop a real understanding of geometric figures and relationships.

Figure 3

Item 17 on Geometry/Measurement



17 As an assignment, you give students a picture of a cone like the one illustrated below and ask them to determine as many different types of cross sections as possible.

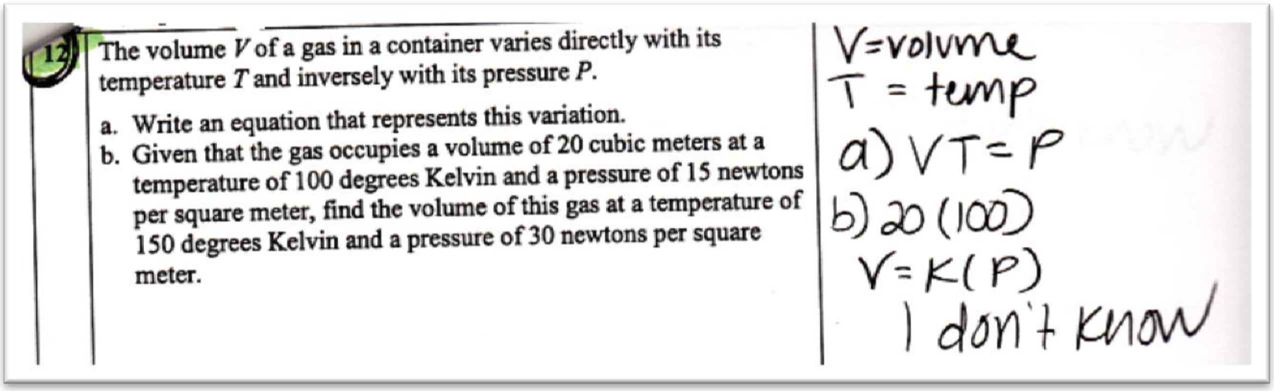
One student draws the three shapes below:

a. Identify the student's limited thinking.
b. Describe how you would help this student understand that there are other different cross-sections.

In Algebraic Ideas, none of the pre-service teachers answered item number 12(b) correctly. This item assessed pre-service teachers' understanding of direct and inverse proportionality. The question pertains to a TExES learning outcome, "To demonstrate an understanding of the connections among linear functions, proportions, and direct variation." The correct answer to 12(a) is "$VP=kT$, where k is the constant of the variations." In the example below, the pre-service teacher provided an incorrect model and did not have the constant, *k*, in the model, which was used in the second part of the question. The second part of the question involves multiple steps in which the constant should be obtained from the known parameters and also applying the model to find the new volume with a different pressure. It is also noticeable that no units were mentioned in the discussion. This answer suggests that pre-service teachers struggle with constructing algebraic models for real-world settings and with using symbols and reasoning in analysis.

Figure 4

Item 12 on Algebraic Ideas



Research Question Three

The third research question asked what the pre-service teachers' perceptions of preparedness for teaching mathematics were. The primary data source used to answer this question was the QUEST anonymous survey.

The 23 completed survey responses were used in this analysis, which includes 14 QUEST 1 respondents and nine of QUEST 2 respondents.

Pre-service teachers' perceptions of preparedness

Table 17 shows how pre-service teachers' perceptions of their preparedness for TExES standards, broken down by the amount of coverage they believed the program provided for each strand of the TExES Standards. This study finds that pre-service teachers do not feel that they are well prepared in Probability/Statistics and Geometry/Measurement, as suggested by more than half of the respondents choosing the limited coverage option. The study also finds that pre-service teachers do not demonstrate a clear pattern for the program's coverage of the other strands.

Table 17

Preparedness for TExES Standards (N=23)

How well do you feel that your program prepared you (or is preparing you) for the following TExES standards?	N	L	M	I
Number Concepts	0.0% (0)	34.8% (8)	52.2% (12)	13.0% (3)
Patterns and Algebra	0.0% (0)	34.8% (8)	39.1% (9)	26.1% (6)
Geometry and Measurement	4.3% (1)	52.2% (12)	30.4% (7)	13.0% (3)
Probability and Statistics	8.7% (2)	56.5% (13)	30.4% (7)	4.3% (1)
Mathematical Processes and Perspectives	0.0% (0)	34.8% (8)	47.8% (11)	17.4% (4)
Mathematical Learning, Instruction, and Assessment	0.0% (0)	43.5% (10)	34.8% (8)	21.7% (5)
The Texas Essential Knowledge and Skills (TEKS) in mathematics 4 – 8	0.0% (0)	43.5% (10)	39.1% (9)	17.4% (4)

Note. For the above analyses:
N= no coverage; L= limited coverage; M= moderate coverage; I= in-depth coverage.

The next table shows how pre-service teachers answered a question about their preparedness for the *NCTM Standards* and the percent of respondents indicating their degree of preparedness with each strand. The table indicates no obvious pattern; most pre-service teachers believe their program provided either limited or moderate coverage.

Table 18

Preparedness for NCTM Standards (N=23)

How well did your program prepare you for the following five process standards of the National Council of Teacher of Mathematics?	N	L	M	I
Problem Solving	4.3% (1)	39.1% (9)	39.1% (9)	17.4%(4)
Reasoning	4.3% (1)	43.5% (10)	39.1% (9)	13.0% (3)
Communication	13.0% (3)	39.1% (9)	30.4% (7)	17.4% (4)
Connections	17.4% (4)	43.5% (10)	21.7% (5)	17.4% (4)
Representation	17.4% (4)	39.1% (9)	21.7% (5)	21.7% (5)

Note. For the above analyses:
N= no coverage; L= limited coverage; M= moderate coverage; I= in-depth coverage.

Table 19 shows participants' responses about the learning process in QUEST in terms of their content knowledge preparedness. Participants reported their degree of agreement from strongly disagree to strongly agree. In the table, percentages are provided for each level. Overall, pre-service teachers were positive about their learning experience in the QUEST program for building a foundation in mathematics, as indicated by a majority choosing "Somewhat agree."

Table 19
Content Knowledge Preparedness (N=23)

The program provided me opportunities to build an adequate foundation in mathematics necessary to be an effective mathematics teacher.	QUEST 1	QUEST 2 & 3
Strongly disagree	7.1% (1)	22.2% (2)
Somewhat disagree	7.1% (1)	22.2% (2)
Neither disagree/agree	14.3% (2)	11.1% (1)
Somewhat agree	57.1% (8)	44.4% (4)
Strongly agree	14.3% (2)	0.0% (0)
Total responses	**100% (14)**	**100% (9)**

As indicated in Table 20, pre-service teachers were positive about their learning experience of building mathematical teaching knowledge overall, as indicated by the majority of respondents choosing “Somewhat agree” or “Strongly agree.” It is noticeable that only one student in QUEST 2 and 3 reported a negative view about the statement.

Table 20

Teaching Knowledge Preparedness (N=23)

The program provided me opportunities to build an adequate foundation in the teaching knowledge necessary to become an effective mathematics teacher.	QUEST 1	QUEST 2/3
Strongly disagree	14.3% (2)	0.0% (0)
Somewhat disagree	7.1% (1)	11.1% (1)
Neither disagree/agree	21.4% (3)	33.3% (3)
Somewhat agree	42.9% (6)	44.4% (4)
Strongly agree	14.3% (2)	11.1% (1)
Total responses	**100% (14)**	**100% (9)**

Pre-service teachers’ perceptions of the level of satisfaction

Table 21 shows pre-service teachers’ satisfaction with the general mathematics courses in the QUEST program, organized by the percent of respondents indicating their degree of satisfaction from “Not satisfying at all” to “Very satisfying.” The majority of the QUEST 1 group reported that they found the general mathematics courses “Moderately satisfying,” yet about 44% of the QUEST 2 group said they found the courses “Not satisfying at all.”

Table 21

Satisfaction with General Mathematics Courses (N=23)

How satisfied are you about the general mathematics courses?	QUEST 1	QUEST 2/3
Not satisfying at all	14.3% (2)	44.4% (4)
Somewhat satisfying	7.1% (1)	11.1% (1)
Not sure	7.1% (1)	11.1% (1)
Moderately satisfying	64.3% (9)	22.2% (2)
Very satisfying	7.1% (1)	11.1% (1)
Total responses	**100% (14)**	**100% (9)**

The following table shows student satisfaction with the mathematics education courses in the QUEST program and the percent of respondents indicating their degree of satisfaction from "Not satisfying at all" to "Very satisfying." The study finds that the majority of pre-service teachers find the mathematics education courses to be either moderately or very satisfying.

Table 22

Satisfaction with Mathematics Education Courses (N=22)

How satisfied are you about the mathematics education courses?	QUEST 1	QUEST 2/3
Not satisfying at all	7.1% (1)	0.0% (0)
Somewhat satisfying	35.7% (5)	37.5% (3)
Not sure	0.0% (0)	12.5% (1)
Moderately satisfying	50.0% (7)	25.0% (2)
Very satisfying	7.1% (1)	25.0% (2)
Total responses	**100% (14)**	**100% (8)**

Satisfaction with the overall program coursework in the QUEST program can be found in Table 23, which shows the percent of respondents indicating their degree of satisfaction from "Not satisfying at all" to "Very satisfying." Although it is noticeable that half of the QUEST 1 group found the overall program coursework "Moderately satisfying," the responses did not offer any clear pattern of student satisfaction with the program coursework.

Table 23

Satisfaction with Program Coursework (N=23)

How satisfied are you about the overall program coursework in the 4-8 mathematics teacher preparation program?	QUEST 1	QUEST 2/3
Not satisfying at all	21.4% (3)	0.0% (0)
Somewhat satisfying	14.3% (2)	33.3% (3)
Not sure	7.1% (1)	44.4% (4)
Moderately satisfying	50.0% (7)	22.2% (2)
Very satisfying	7.1% (1)	0.0% (0)
Total responses	**100% (14)**	**100% (9)**

Pre-service teachers' recommendations and constructed responses

Participants' written comments provided specifics about the three research questions, especially regarding the efficacy of particular courses/instructors and recommendations for program improvement.

Table 24

Frequency of Reponses for Emerging Themes (N=23)

Five Themes	*n*	% by Themes
More and early exposure to pedagogical methods taught by the math educator	14	60.8%
The same instructor fatigue	9	39.1%
Teacher development through "doing":	7	30.4%
Low confidence in content knowledge:	7	30.4%
Calling for streamlined administrative functions	5	21.7%
Total Possible Responses	23	

Five themes emerged. Table 24 provides the number of times each theme was found in student comments and the percent of occurrence (out of 23, the number of survey participants.)

Below, three examples of comments that were deemed to espouse a theme are presented and each theme is briefly explained. (Course number 7777 and the pseudonym Jane/John Doe are used to protect anonymity.)

More and early exposure to pedagogical methods taught by the math educator. Pre-service teachers wanted to have the opportunity to learn in the manner that they would expect their own students to learn math. Many expressed that they appreciated the opportunity to learn pedagogical methods from a math educator (as opposed to the lecture style format most common in traditional university classrooms). Pre-service teachers indicated that although advanced college-level mathematics presented by a mathematician is meant to be good, a math educator offers more opportunity to learn about teaching mathematics.

- "CUIN 7777 is the only course I have taken so far that makes me feel like I am really learning about how to teach"
- "I think a primary focus should be like this is how you could teach it to your future students"
- "Why we learn these important things in QUEST 2 instead of QUEST 1??? Why don't QUEST use math educators in their department in QUEST 1 math courses???"

The same instructor fatigue. Pre-service teachers wanted to experience various instructors in mathematics content courses.

- "I did not like John/Jane Doe was the only professor teaching the Math classes"

- "Did not like that only one teacher taught all the courses"
- "We need more of a variety of math teachers to choose from"

Teacher development through "doing". There was a consensus that pre-service teachers wanted to learn mathematics and its pedagogy by actively participating in teaching activities as practicing teachers would in the classroom, tailored to the grade level they plan to teach in the future.

- "The program needs more hands on teaching experience and learning to teach to students"
- "I think the program needs to allow us to spend MORE time in the classroom and learning how to work with the students"
- "When the teacher makes us to work together and learn to how to teach, that's what i really need and i appreciate it. But sometimes they talk too much about research and too much reading, and nothing about how to connect what we discuss to actually teaching situation"

Low confidence in content knowledge. Pre-service teachers openly talked about how much they were concerned about their lack of content knowledge in mathematics.

- "I feel that I am well prepared to teach a class in an organized manner; however, I do not feel as proficient in my content area"
- "Honestly, I have no idea when it comes to college mathematics. I am not good at math but I do want to be a good math teacher; but I don't think the math teachers prepare me for my career goal"
- "I feel completely unprepared to teach math in middle school"

Calling for streamlined administrative framework. Several pre-service teachers mentioned a need to have more cohesive advising and more structured dissemination of information about routine administrative functions in the program.

Responses were not focused enough to say anything conclusive about the efficacy of administrative components of the QUEST program.

- "I think that more planning and care should go into these decisions"
- "I want to have a handbook more like information or step-by-step guideline on how to move on from QUEST 1 to 2 and 3. QUEST handbook needs to be re-written with more clear and consistent guideline, who to talk to when we have a particular problem and who has the authority to make things happen"
- "I think QUEST needs more cohesive planning as we move from QUEST 1, 2 and to QUEST 3. Advisers don't have manuals"

Summary

The study found evidence that mathematics courses met state standards (83%) and mathematics education courses adequately met standards (100%). Combined together, the overall alignment of the coursework with state standards in terms of learning outcome coverage was 91% (138 out of 152 learning outcomes). DTAMS results indicated that (1) pre-service teachers displayed the strongest knowledge in Number Computation, followed by Algebraic Ideas, Geometry/Measurement, and Probability/Statistics, and that (2) pre-service teachers displayed the highest scores for Memorized/Factual Knowledge, followed by Conceptual Understanding, Reasoning/Problem Solving, and Pedagogical Content Knowledge. Pre-service teachers had higher Memorized/Factual Knowledge than Pedagogical Content Knowledge. The pre-service teachers' overall content knowledge was not strong, and the two lowest-performing content knowledge areas were Geometry/Measurement and Probability/Statistics. The QUEST anonymous survey also provided information about how pre-service teachers felt about their preparedness for teaching. Additionally, pre-service teachers' written comments in the survey allowed the study to elicit five themes about their perspectives on their knowledge and learning in the program.

CHAPTER FIVE

Discussion

The purpose of this study was to evaluate the 4 – 8 mathematics certification components of the QUEST program at the University of Houston. It intended to then provide recommendations for improvement as well as for further investigation as part of ongoing systematic program evaluations. Toward these goals, the 4 – 8 mathematics education QUEST program was assessed in terms of the following: (1) course alignment with state standards, (2) the current state of 4 – 8 mathematics pre-service teachers' content and pedagogical content knowledge, and (3) pre-service teachers' perceptions about the program. The previous chapter stated the results. This chapter will discuss those results, consider the implications for teacher education practice, and make recommendations for improvement and further investigations.

Research Question One: Alignment with State Standards

To what extent is the 4-8 mathematics teacher preparation program consistent with state standards for mathematics teacher preparation?

An examination of the extent to which the 4 – 8 mathematics teacher preparation program is consistent with state standards for mathematics teacher preparation finds two patterns of teacher education practice in the QUEST coursework.

Mathematics courses. The analysis of course documents (mainly syllabi) indicated that the mathematics courses covered 83% of the TExES learning outcomes.

The course syllabi did not provide information pertaining to how instructors ascertained their students' mastery of mathematical knowledge and skills and identified disparate levels of student understanding on a specific list of knowledge and skills. In turn, the lack of data about what guides instruction and how the efficacy of instruction is measured and sustained could result in the challenging reality for mathematics *education* instructors in subsequent courses. In fact, the DTAMS data suggest that perhaps the content was not covered, even though it was listed on the syllabi. Also, if such a high percentage of learning outcomes (83%) are addressed by the mathematics courses, then why are the DTAMS low? This study reports the gap and provides plausible explanations in this chapter. Nonetheless, further work should be done to find answers. In that sense, the QUEST program can benefit from future studies with a clear sense of whether or not pre-service teachers have taken the mathematics courses before taking the DTAMS to understand better regarding (1) whether the DTAMS are appropriate measures of the courses and (2) whether standards addressed in syllabi are implemented appropriately.

Mathematics education courses. The study found sufficient evidence that the mathematics education courses adopted state *and* national standards and used student learning outcomes to guide teaching and learning activities. The course syllabi showed explicit intent by course instructors to link student learning outcomes to assessment methods. Moreover, education course syllabi served as a comprehensive reference regarding course organization, instructors' framework for teaching and learning, class activities, and evaluation, including expectations, methodology, and rubrics. The syllabi provided a clear picture of what was to be taught, what guided instruction, what level of mastery was expected and how students' knowledge and skills were measured. As reported on the survey, pre-service teachers seemed to recognize the change of dynamics and teaching practice from mathematics courses in the early phase of QUEST to mathematics education courses. Unlike the QUEST 1 group, the QUEST 2 pre-service teachers expressed dissatisfaction with the mathematics courses *after* they started taking a mathematics education course. In the survey, QUEST 2 pre-service teachers indicated a disconnect between the depth espoused by the mathematics course instructors and the mathematical thinking and reasoning appropriate for the grade level at which pre-service teachers plan to teach. Some mentioned a need to bridge college mathematics content to middle school curriculum.

Implications

The discrepancy in how well mathematic and mathematics education courses align with standards is problematic at two different levels. One solution would be to increase collaborative efforts across the two departments to improve syllabi while aligning curriculum, instruction, and assessment with content standards. Such collaboration can help integrate learning outcomes instead of creating the dichotomy of mathematics versus and mathematics education so that the coursework might become more effective with a shared responsibility for covering standards. Doing so is especially important because the U.S. Department Education demands that programs preparing mathematics teachers take into account the full range of standards in order to ensure their students achieve the requisite skills and knowledge and to participate in evaluating the changes systematically (Slavin, 2002). At a deeper level, the discrepancy in alignment with standards can be an indicator of a different level of interest and commitment to teacher education between departments. This may require some consensus seeking and executive efforts to increase the commitment to teacher education. College and University Responsibilities for Mathematics Teacher Education (MAA, 1991) provided specific recommendations for leadership and support of those who are engaged in mathematics education for pre-service teachers (Leitzel, 1991). Recommendations of particular relevance to this study are as follows:

- All individuals who teach pre-service teachers should have substantial backgrounds in mathematics and mathematics education.
- Those who teach pre-service teachers should have regular and lively contact with faculty in both mathematics and education departments by regular meetings, seminars, joint faculty appointments, and other cooperative projects.
- Faculty advisors should encourage their mathematically talented students to consider teaching careers.
- Tenure, promotion, and salary decisions for faculty members who teach pre-service mathematics teachers should be based on teaching, service, and scholarly activity that includes research in mathematics education.

Research Question Two: Content and Pedagogical Content Knowledge

What content and pedagogical content knowledge can 4-8 mathematics pre-service teachers demonstrate at their respective points in the program?

Weak Content Knowledge. The most noticeable result was the overall low performance of pre-service teachers on the four assessments of both content and pedagogical content knowledge. The study considers two major reasons for this poor performance. First, the pre-service teachers might have not taken the testing seriously since they were explicitly told that the results were going to remain anonymous, which may have decreased motivation. In fact, a review of student written responses suggested that the rate of incomplete responses was too high to ignore. Incomplete responses may indicate a lack of effort on the part of pre-service teachers. Second, the overall poor performance may reveal that the pre-service teachers simply did not have strong content knowledge. It is also probable that some pre-service teachers had not taken the coursework yet.

The examination of student answers might provide a window into the current status of pre-service teachers' knowledge of mathematics and its teaching, supporting the conclusion that a lack of basic content knowledge has resulted in unsatisfactory performance on the DTAMS. Indeed, it is problematic that DTAMS scores were low, particularly for the QUEST 2 students since the QUEST 2 phase marks the end of coursework with the student-teaching experience scheduled for the following semester. The level of mathematics knowledge tested by DTAMS was actually within the scope of middle and secondary grade levels. Although it is unknown why QUEST 2 DTAMS scores were consistently lower than QUEST 1 scores, this study found that pre-service teachers who completed the general mathematics courses still struggled with all four content areas of the DTAMS. This finding raises concern that weak content knowledge could undermine the salient efforts of faculty members to educate effective mathematics teachers in areas such as curriculum design, children's thinking, communication of mathematical concepts, and persistence in problem solving.

Research suggests that solid content knowledge is a basis for strong pedagogical content knowledge (Schoenfeld, 2007). This study's results support this argument; pre-service teachers' pedagogical content knowledge scores were never higher than their content knowledge scores. Another interesting result is that most content knowledge scores in four content area assessments across both QUEST 1 and QUEST 2 have higher standard deviations; this indicates the various knowledge levels when it comes to pre-service teachers' content knowledge in the program. Pre-service teachers' written comments on the survey support this finding. Specifically, a number of pre-service teachers expressed a lack of interest in learning basic mathematics since they felt they had sufficient content knowledge and wanted to be introduced to pedagogical training earlier in the program. About the same number of respondents also openly expressed low confidence in their content knowledge. Taken together, these findings indicate QUEST pre-service teachers are a group with diverse needs. Their various needs regarding content knowledge make it difficult for instructors to provide focused instruction with consistency in delivery and content. An effective administrative action might be to set a higher GPA standard for admission into QUEST by using applicants' grades in general mathematics courses. However, when mathematics courses do not have adopted standards-based education, a role of the mathematics courses to certify successful completion of college-level math is likely to be limited. Alternatively, the use of DTAMS as a benchmark test for admission could be considered. However, caution remains about high-stakes standardized testing. For this reason, the study suggests that the mathematics faculty, the mathematics education faculty, and administrators from the respective departments collaborate with a renewed focus on course alignment and building a reliable assessment system for the mathematics courses for pre-service teachers.

Implications. The DTAMS results and the survey findings indicate that Probability/Statistics and Geometry/Measurement are the two major content areas in need of a change. Also, courses covering Number Theory or Problem Solving have not contributed much to increase the pre-service teachers' content knowledge, conceptual knowledge, and problem-solving skills. The clear pattern of giving up on a mathematics problem too easily in DTAMS points to a low level of persistence in problem solving. Responding to a need for coursework redesign, courses such as Math 2311 (Introduction to Probability and Statistics), Math 3305 (Formal and Informal Geometry), and Math 3306 (Problem Solving in Mathematics) can benefit from co-teaching delivered by the mathematics educator and the mathematician faculty with a shared commitment to the school curriculum. This change might satisfy pre-service teachers' need for an exposure to pedagogy as well as learning mathematical ideas meaningfully and directly connected to the school curriculum. Good school mathematics instruction involves a combination of mathematical knowledge and pedagogy. Mathematics educators can provide valuable insights and information about what takes place in school classrooms. They have access to information on state curriculum guidelines and research studies on teachers' mathematical knowledge. A math educator can validate college-level mathematical topics that might otherwise seem irrelevant to teaching by indicating how they might appear in the school classroom. In return, mathematics faculty can keep mathematics education faculty informed of mathematical developments that have an impact on school mathematics. In this way, co-teaching can also serve as a concrete step to foster cooperation between these two groups. If co-teaching led to student success, it could spread to other mathematics courses in the QUEST program, and this collaboration could inform coursework redesigning.

Research Question Three: Perceptions of Preparedness for Teaching Mathematics

What are the pre-service teachers' perceptions of preparedness for teaching mathematics?

The survey findings indicate that, overall, pre-service teachers think positively about their preparation for teaching mathematics. However, pre-service teachers' written responses provided something significant about the QUEST program, which DTAMS data or course documents might have not fully revealed. The study presents three focal themes: (1) Low confidence in content knowledge, (2) Early exposure to pedagogy, and (3) Tie theory to practice. In the initial analysis, pre-service teachers' written responses were categorized into five themes. The study also indicates one more area worthy of further research.

Low confidence in content knowledge. Pre-service teachers expressed a low level of confidence in their mathematics content knowledge. This finding supports their low DTAMS scores in the content knowledge area and indeed points to a very definitive problem for the program's future. Adequate content knowledge at an appropriate grade level is a fundamental basis of professional knowledge and skills for effective mathematics teachers. Low content knowledge can limit the impact of strong pedagogical training. As a result, the ability of mathematics education faculty to develop pre-service teachers' pedagogical capacity has been unproductive despite thoughtful planning and meaningful activities. This echoes the urgent need for increasing pre-service teachers' content knowledge. A short-term solution could be increasing QUEST admission and advancement standards using applicants' score on a content exam recommended by faculty members with expertise in content and pedagogy standards at the state and national level. Long-term solutions could include re-designing mathematics courses so that they provide clear learning outcomes, developing appropriate assessment methods to measure the learning outcomes, using assessment data for program evaluation, and working together within and across university departments to implement changes.

Early exposure to pedagogy. Pre-service teachers wanted more and early exposure to pedagogical methods in the program. Pre-service teachers in the program take mathematics courses from the Mathematics Department, and the instructors appeared to teach content knowledge with the same methods they would employ for science/engineering majors. In the midst of reform in mathematics education, pre-service teachers ought to learn mathematics in the manner in which they will be teaching it, which is unlike the lecture format in traditional classrooms. The survey data suggest that mathematics courses are currently not successful in addressing mathematical topics for future teachers in a way that connects undergraduate coursework to school mathematics. Studies show that mathematics departments where undergraduate programs are secondary to research do not provide incentives for the instructors to develop effective teaching practices in collaboration with mathematics educators (Heaton & Lewis, 2011). Mathematics courses need to have a renewed focus on providing powerful learning experiences for pre-service teachers. This is also well articulated in the Conference Board of Mathematical Sciences (CBMS, 2001), a landmark study with recommendations made by research mathematicians and mathematics educators for the undergraduate mathematical education of future teachers. The report echoes MAA recommendations. Key recommendations of the CBMS report suggest that it is important for the entire mathematics faculty to actively support teacher education efforts and for mathematics departments to devote resources to designing and offering courses for teachers. Specifically, the recommendations urge mathematics departments to reward and publicize faculty members involved in teacher education. Additionally, it is suggested that mathematics faculty and mathematics education faculty collaborate to provide co-teaching of mathematics courses.

Tie theory to practice. Pre-service teachers reported that they want to learn to teach by actually practicing teaching. Learning by doing is indeed an effective way to attain teaching competency. However, the student-teaching opportunity is limited. Pre-service teachers would benefit from more opportunities to participate in realistic teaching tasks, such as mock teaching with a specific grade level in mind.

Finally, pre-service teachers wanted more streamlined administrative framework of the QUEST program. Many complaints about advising related to field experience. The QUEST program is large and administrative issues are inevitable. However, some pre-service teachers also wanted more streamlined and documented procedures so that routine administrative functions are carried out with a uniform and consistent framework of procedures and principles. In this sense, it can be beneficial to investigate ways of improving the program's administrative framework, including routine procedures, responsibility charts, and availability of program documents for specific actions.

Recommendations

This study formulated recommendations that can be grouped into two major categories based on who receives them: administrators and researchers.

Recommendations for administrators are as follows:

- The Mathematics Department should develop and sustain systematic evaluations, which include (1) conceptualizing learning outcomes based on state and national standards and (2) documenting teaching practices and learning activities aligned with state and national standards.
- QUEST administration should review the QUEST program admission and advancement criteria regarding the required level of content knowledge in mathematics.
- The Department of Curriculum and Instruction and the Mathematics Department should address the need for co-teaching of mathematics courses for pre-service teachers.
- QUEST administration should institute QUEST faculty meetings to share syllabi, goals, teaching practice, and intentions of the courses.
- QUEST administration should institute evidence-based course evaluations at various points of the program so that the mathematics education program area coordinator and instructors make course corrections as needed.

Recommendations for future studies are as follows:

This study calls for further study in two main directions. First, the study was a snapshot with limited data and participation. Thus, clearly, replication is needed, especially with DTAMS data, a larger number of participants, clearer information about pre-service teachers' completed coursework at the time of the study, and improved survey instruments. Some of the survey questions were not successful in eliciting disparate levels of responses. There are a few plausible reasons for this finding. First, the standards mentioned in the survey were not descriptive enough for pre-service teachers to critically think about their preparedness. Second, pre-service teachers were not clear about which courses were mathematics and which were the mathematics education courses. They recognized courses better with a course title or a name of the instructors. More specific recommendations are as follows:

- Pre-service teachers should be motivated to try harder in DTAMS testing.
- More pre-service teachers should participate in DTAMS testing. (With more test scores, for example, the study could have further explored why the QUEST 2 group performed more poorly than the QUEST 1 group on the DTAMS.)
- Research should collect the individual list of complete courses, such as unofficial transcripts, and link this data to DTAMS scores.
- The QUEST Anonymous Survey should be improved such that items use more descriptive words, provide specific course titles, avoid educational jargons, and not ask about the *NCTM Standards* in the early phases of the program.
- Research should attempt to ensure more survey participation by using a more focused listserv and developing a system that maintains anonymity yet is persistent with non-respondents.
- Research should consider conducting face-to-face interviews with pre-service teachers.

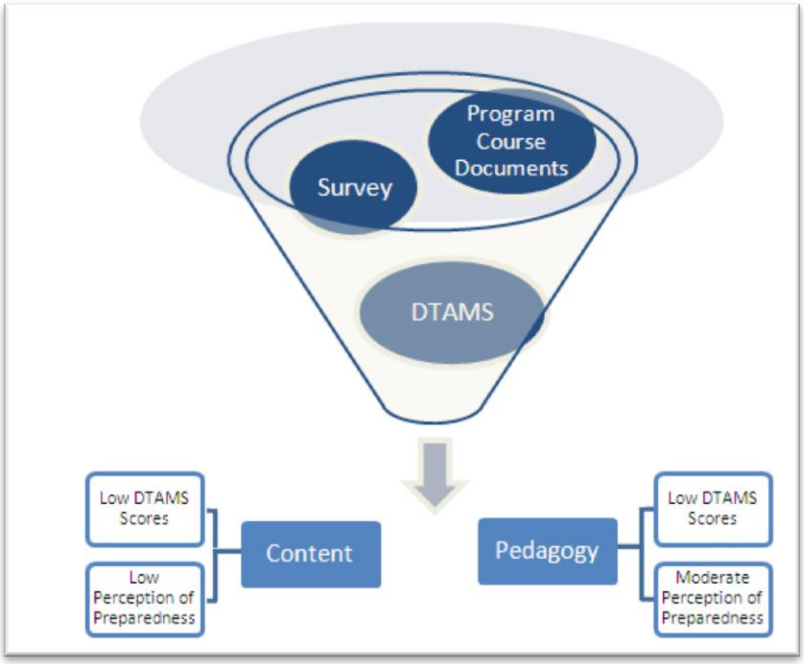
The second direction for future research is to continue the line of work that examines what experiences pre-service mathematics teachers need in order to improve their content knowledge and increase their pedagogical content knowledge. With the limited design of this study, mathematics courses remained inaccessible regarding how mathematics are taught, how students are evaluated, and how this evaluation informs instruction. Future research should explore ways to look inside the mathematics classroom, conduct interviews with instructors as well as pre-service teachers. This can allow researchers to find evidence how intended curriculum aligned with standards remain purposeful with implemented curriculum. In addition, a study about the extent to which mathematics and mathematics education courses use assessment data about student leaning outcomes to improve the courses is necessary. In that sense, future studies in the following areas could enrich the ongoing systematic evaluation of mathematics components within the QUEST program:

- Studies about the implementation of intended curriculum
- Studies about mathematics content courses for pre-service teachers taught by the mathematics education faculty including the efficacy of co-teaching
- Studies about increasing pre-service teacher persistence in problem solving

Summary

As illustrated in the following figure, this study has attempted to provide a snapshot of QUEST pre-service 4 – 8 mathematics teachers by assessing course alignment with state standards, teacher knowledge, and pre-service teachers' perceptions of preparedness. The study used DTAMS data, an anonymous survey, and QUEST program/course documents.

Figure 5
Overview of Evaluation



It appears that the QUEST program is successful at initiating systematic evidence-based evaluations for change. Overall, pre-service teachers remain positive about their learning experience in the program and express a passion for attaining the knowledge of pedagogy. In particular, pre-service teachers supported positive learning experience in the courses taught by mathematics educators at the Department of Curriculum and Instruction. This supports the QUEST program's response to the call for changes in mathematics teacher preparation given concurrent changes in the emerging school curriculum. A significant underlying question was to reconcile why salient efforts exerted by the mathematics education faculty resulted in low DTAMS scores. As a result, the picture emerging from this study is of a pre-service teacher dedicated to teaching yet demonstrating low knowledge of content and pedagogy. The study posits that pre-service teachers' low content knowledge is likely responsible, as it is difficult for mathematics education faculty to build a pedagogical prowess upon low confidence and knowledge in mathematical content.

Solutions to increase mathematics knowledge may lie in how and what mathematics is actually taught. The study finds that the current mathematics courses cover the TExES Standards adequately. However, there existed unclear alignment of standards with learning outcomes. More importantly, how the curriculum is being implemented is still unknown. In order for teachers to implement the standards-based curriculum, they must have opportunities in college courses to perform mathematics as they will teach it and to learn how to teach mathematics in step with the emerging school curriculum. In that sense, the QUEST program can benefit from conducting a study on the process of pre-service teachers' learning of college mathematics. Meanwhile, evaluating a teacher education program should not only examine whether pre-service teachers are increasing pedagogical capacity but also ascertain how the program operates within the shared responsibilities that encourage involvement and build commitment from everyone including faculty, administrators, and pre-service teachers towards a vision of meaningful experiences in mathematics.

References

Allen, M.J., & Yen, W. M. (2002). *Introduction to Measurement Theory.* Long Grove, IL: Waveland Press.

Allgood, W. & Rice, J.K. (2002). The adequacy of urban education: Focusing on teacher quality. In C.F. Roellke & J.K. Rice (Eds.), *Fiscal policy issues in urban education* (pp. 155-180). Greenwich, CT: Information Age Publishing, Inc.

Andrew, M. D., & Schwab, R. L. (1995). Has reform in teacher education influenced teacher performance? An outcome assessment of graduates of an eleven-university consortium. *Action in Teacher Education, 17*(3), 43–53.

Baker, E. L. (2004). *Aligning curriculum, standards, and assessments: Fulfilling the promise of school reform.* Los Angeles: National Center for Research on Evaluation, Standards, and Student testing.

Ball, D. L. (1999). Crossing boundaries to examine the mathematics entailed in elementary teaching. *Contemporary mathematics, 243*, 15-36.

Ball, D. L., & Feiman-Nemser, S. (1988). Using textbooks and teachers' guides: A dilemma for beginning teachers and teacher educators. *Curriculum Inquiry, 18*, 401-423.

Ball, D. L., & Forzani, F. M. (2009). The work of teaching and the challenge for teacher education. *Journal of Teacher Education, 60*(5), 297-511.

Ball, D. L., Hill, H. C., & Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade, and how can we decide? *American Educator*, *29*(3), 14-22, 43-46.

Ball, D. L., Lubienski, S., & Mewborn, D. (2001). Research on teaching mathematics: The unsolved problem of teachers' mathematical knowledge. In V. Richardson (Ed.), *Handbook of research on teaching* (4th ed., pp. 433-456). New York: Macmillan.

Ball, D. L., Sleep, L., Boerst, T., & Bass, H. (2009). Combining the development of practice and the practice of development in teacher education. *Elementary School Journal*, *109*, 458 - 476.

Berliner, D. C. (2004). Describing the behavior and documenting the accomplishments of expert teachers. *Bulletin of Science, Technology, and Society, 24*(3), 200-212.

Borko, H., & Whitcomb, J. A. (2008). Teachers, teaching, and teacher education: Comments on the national mathematics advisory panel's report**.** *Educational Researcher*, *37*(9), 565–572.

Braun, J. A., & Crumpler, T. P. (2004). The social memoir: An analysis of developing reflective ability in a pre-service methods course. *Teaching and Teacher Education, 20,* 59 – 75.

Bristor, V. J., Kinzer, S., Lapp, S., & Ridener, B. (2002). The Teacher Education Alliance (TEA): A model teacher preparation program for the twenty-first century. *Education,122*(4), 688-700.

Conference Board of the Mathematical Sciences. (2000). *CBMS Mathematical education of teachers project: Draft Report*. Washing DC.

Cochran-Smith, M. (2001). Constructing outcomes in teacher education: Policy, practice and pitfalls. *Education Policy Analysis Archives, 9* (11). Retrieved May 4, 2010 from http://epaa.asu.edu/epaa/vol9.html.

Darling-Hammond, L. (2000). Teacher quality and student achievement. A review of state policy evidence. *Educational Policy Analysis Archives*, 8(1). Retrieved November 1, 2005, from http://www.epaa.asu.edu/paa/v8n1.

Darling-Hammond, L. (2003). 'Steady Work': The Ongoing Redesign of the Stanford Teacher Education Program. *Educational Perspectives, 36*(1), 8-19.

Darling-Hammond, L. (2006). *Powerful teacher education: Lessons from exemplary programs.* San Francisco: John Wiley & Sons, Inc.

Darling-Hammond, L., Chung, R., & Frelow, F. (2002). Variation in teacher preparation: How well do different pathways prepare teachers to teach? *Journal of Teacher Education, 54*, 286–302.

Darling-Hammond, L., Eiler, M., & Marcus, A. (2002). Perceptions of preparation: Using survey data to assess teacher education outcomes. *Issues in Teacher Education, 11*(1), 65–84.

Dean, C. B., & Lauer, P. A. (2003). *Systematic evaluation for continuous improvement of teacher preparation: Cross-case analysis.* Aurora, CO: Mid-continent Research for Education and Learning.

DeBellis, V.A., & Rosenstein, J.G. (2007). Creating an Equitable Learning Environment for K-8 Teachers of Mathematics. In G. Martin & M. Strutchens (Eds.), *The Learning of Mathematics, NCTM 2007 Yearbook.* Reston, VA: NCTM.

Delaney, A. M. (1995). *Promoting responsive teacher education through effective follow-up studies.* Paper presented at the annual meeting of the American Educational Research Association, San Francisco.

Diez, M. E. (Ed.). (1998). *Changing the practice of teacher education: Standards and assessment as a lever for change.* Washington D.C.: American Association of Colleges for Teacher Education.

Elliott, E, J.. (2003). *Assessing education candidate performance: A look at changing practices*. Washington, DC: National Council for Accreditation of Teacher Education.

Evers, W. M., & Walberg, H. J. (2002). *School accountability*. Stanford: Hoover Institution Press.

Fabiano, L. (1999). *Measuring teacher qualifications (NCES-WP-1999-04).* Washington, DC: U.S. Department of Education, National Center for Educational Statistics.

Frykholm, J. A. (1996). Pre-service teachers in mathematics: Struggling with the Standards. *Teaching and Teacher Education, 12*(1), 665-682.

Frykholm, J. A. (1999). The Impact of Reform: Challenges for mathematics teacher preparation. *Journal of Mathematics Teacher Education. 2*(1), 79-105.

Frykholm, J. A. (2004). Teachers' tolerance for discomfort: Implications for curricular reform in mathematics. *Journal of Curriculum and Supervision, 19*(2), 125-149.

Frykholm, J. A. (2005). Innovative curricula: Catalysts for reform in mathematics teacher education. *Action in Teacher Education, 26*(4), 20-36.

Goldsmith, L. T., & Mark, J. (1999). What is a standard-based mathematics curriculum? *Educational Leadership, 57*(3), 40-44.

Gómez, P., & Rico, L. (2004). *Learning within communities of practice in pre-service secondary school teachers education.* Paper presented at CERME IV, Sant Feliu de Guíxols, Spain. Retrieved September 8, 2010 from http://cerme4.crm.es/Papers%20definitius/12/wg12papers.htm.

Goos, M., & Moni, K. (2001). Modeling professional practice: A collaborative approach to developing criteria and standards-based assessment in pre-service teacher education courses. *Assessment & Evaluation in Higher Education, 26*(1), 73-88.

Graham, K. J., & Fennell, F. (2001). Principles and standards for school mathematics and teacher education: Preparing and empowering teachers. *School Science and Mathematics, 101*(6), 319-327.

Grant, T. J., & Kline, K. (2000, April). *Understanding teachers' changing beliefs and practice while implementing a reform curriculum.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

Grossman, P. L. (1990). *The making of a teacher: Teacher knowledge and teacher education.* New York: Teachers College Press.

Hall, G. E., Smith, C., & Nowinski, M. B. (2005). An organizing framework for using evidence-based assessments to improve teaching and learning in teacher education programs. *Teacher Education Quarterly, 32*(3), 19-33.

Harbison, R.W., & Hanushek, E. A. (1992). *Educational performance for the poor: Lessons from rural northeast Brazil*. Oxford, UK: Oxford University Press.

Heaton, R., M. (2000). *Teaching mathematics to the new standards: Relearning the dance*. New York: Teachers College Press.

Heaton, R. M., & Lewis, W. J. (2011). A mathematician-mathematics educator partnership to teach teachers. *Notices of the AMS, 58*(3), 394 – 400.

Henn-Reinke, K., & Kies, K. M. (1998). Supporting change in teacher education institutions. In M. E. Diez (Ed.), *Changing the practice of teacher education: Standards and assessment as a lever for change* (pp. 157−167). Washington, DC: American Association of Colleges for Teacher Education.

Herman, J. L., Web, N. M., & Zuniga, S. A. (2005). Measurement issues in the alignment of standards and assessments: A case study. *Applied Measurement in Education, 20*(1), 101 – 126.

Hiebert, J. (2003). What research says about the NCTM standards. In J. Kilpatrick, W. G. Marin & D. Schrifter (Eds.), A research companion to principles and standards for school mathematics (pp. 5-23). Reston, VA: NCTM.

Hiebert, J., Morris, A. K., Berk, D., & Jansen, A. (2007). Preparing teachers to learn from teaching. *Journal of Teacher Education*, *58*, 47-61.

Hill, H.C., Rowan, B., & Ball, D.L. (2005) Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*, 371-406.

Hill, H.C., Schilling, S.G., & Ball, D.L. (2004) Developing measures of teachers' mathematics knowledge for teaching. *Elementary School Journal 105*, 11-30.

Howey, K. R., & Zimpher, N. L. (1999). Pervasive problems and issues in teacher education. In G. A. Griffin (Ed.), *The education of teachers* (pp. 279−305). Chicago: University of Chicago Press.

Kinach, B. M. (2002). Understanding and learning-to-explain by representing mathematics: Epistemological dilemmas facing teacher educators in the secondary mathematics "methods" course. *Journal of Mathematics Teacher Education, 5,* 153 – 186.

Kuhs, T., & Ball, D. (1986). *Approaches to teaching mathematics: Mapping the domains of knowledge, skills and dispositions*. Retrieved November 1, 2010 from http://staff.lib.msu.edu/corby/education

La Marca, P. M., Redfield, D., & Winter, P.C. (2000*). State standards and state assessment systems: A guide to alignment.* Washington, DC: Council of Chief State School Officers.

Larson, M. (2002). *Essential characteristics of effective mathematics instruction*. Houghton Mifflin Mathematics.

Latterell, C. M. (2008, May). A snapshot of ten preservice secondary mathematics teachers. *Issues in the Undergraduate Mathematics Preparation of School Teachers: The Journal*, Volume 1 (Content Knowledge). Retrieved January 9, 2011 from http://www.k-12prep.math.ttu.edu.

Leitzel, J. R. (Ed.) (1991). *A call for change: Recommendations for mathematical preparation of teachers of mathematics.* Washington, DC: The Mathematical Association of America, Committee on the Mathematical Education of Teachers.

Liljedahl, P., Rolka, K., & Rösken, B. (2007). Affecting affect: The re-education of preservice teachers' beliefs about mathematics and mathematics learning and teaching. In M. Strutchens, & W. Martin (Eds.), *69th NCTM Yearbook – The Learning of Mathematics* (pp. 319-330). Reston, VA: National Council of Teachers of Mathematics.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, NJ: Lawrence Erlbaum Associates.

Mathematical Association of America. (1991). *A call for change: Recommendations on the mathematical preparation of teachers of mathematics.* Washington, DC: The Association.

Mewborn, D. S., & Cross, D. I. (2007). Mathematics teachers' beliefs about mathematics and links to students' learning. In W. G. Martin, M. E. Strutchens, & P. C. Elliot (Eds.), *The learning of mathematics* (pp. 259-269). Reston, VA: NCTM.

Mohr, M. (2006). Mathematics knowledge for teaching. *School Science and Mathematics, 106*(6), 9.

Monk, D. H. (1994). Subject area preparation of secondary mathematics and science teachers and student achievement. *Economics of Education Review, 13*(2), 125–145.

Morris, A. K., Hiebert, J., & Spitzer, S. M. (2009). Mathematical knowledge for teaching in planning and evaluating instruction: What can preservice teachers learn? *Journal for Research in Mathematics Education, 40*, 491–529.

Mullens, J. E., Murnane, R. J., & Willett, J. B. (1996). The contribution of training and subject matter knowledge to teaching effectiveness: A multilevel analysis of longitudinal evidence from Belize. *Comparative Education Review*, *40*, 139-157.

Murnane, R. J., & Steele, J. L. (2007). What is the problem? The challenge of providing effective teachers for all children. *The Future of Children 17*(1), 15-43.

National Council for Accreditation of Teacher Education. (2002). *Professional standards for the accreditation of schools, colleges, and departments of education*. Washington, D.C.: Author.

National Council of Teachers of Mathematics. (1989) *Curriculum and evaluation standards for school mathematics*. Reston, Va.: Author

National Council of Teachers of Mathematics. (2000). *Principle and standards for school mathematics*. Reston, VA: Author.

Peterson, K. (1989). Teacher education program evaluation through an institutional board review of graduates. *Journal of Research and Development in Education, 22*(4).

Rice, J.K. (2009). *High-stakes accountability: Implications for resources and capacity.* Greenwich, CT: Information Age Publishing.

Riordan, J. E., & Noyce, P. E. (2001). The impact of two standards-based mathematics curricula on student achievement in Massachusetts. *Journal for Research in Mathematics Education, 32*(4), 368-398.

Robinson, E. E., Robinson, M. F., & Maceli, J. C. (2000). The impact of standards-based instructional materials in mathematics in the classroom. *Yearbook (National Council of Teachers of Mathematics), 2000*, 112-126.

Rothstein, R. (2008). Leaving "No Child Left Behind" Behind. *The American Prospect*. *19*(1), 50-51, 53-54.

Saderholm, J., Ronau, R., Todd Brown, E., & Collins, G. (2010). Validation of the Diagnostic Teacher Assessment of Mathematics and Science (DTAMS) Instrument. *School Science and Mathematics, 110*(4), 180-192.

Schoenfeld, A. H. (2007). The complexities of assessing teacher knowledge. *Measurement: Interdisciplinary research and perspectives, 5*(2), 198 – 204.

Sherin, M. G. (2002). When teaching becomes learning. *Cognition and Instruction, 20*(2), 119-150.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.

Slavin, R. (2002). Evidence-based education policies: Transforming educational practice and research. *Educational Researcher, 31*(7), 15-21.

Smith, T. M., Desimone, L. M., & Ueno, K. (2005). "Highly qualified to do what? The relationship between NCLB teacher quality mandates and the use of reform-oriented instructional strategies in middle school math" *Educational Evaluation and Policy Analysis 27*(1), 75-109.

Tatto, M. T., Schwille, J., Senk, S., Ingvarson, L., Peck, R., & Rowley, G. (2008). *Teacher Education and Development Study in Mathematics (TEDS-M)*. East Lansing, MI: Teacher Education and Development International Study Center, College of Education, Michigan State University.

Taylor, P. M. (2002). Implementing the standards: Keys to establishing positive professionalism inertia in pre-service mathematics teachers. *School Science & Mathematics, 102*(3), 137-143.

Vogler, K. E. (2002). The impact of high-stakes, state-mandated performance assessment on teachers' instructional practices. *Education*, *123*(1), 39-55.

Wayne, A. J., & Youngs, P. (2003). Teacher characteristics and student achievement gains: A review. *Review of Educational Research*, *73*(1), 89 – 122.

Webb, N. L. (1999). *Alignment of science and mathematics standards and assessments in four states* (Research monograph, No. 18.). Madison: National Institute for Science Education.

Weiss, I. R., Pasley, J. D., Smith, P. S., Banilower, E. R., & Heck, D. J. (2003). *Looking inside the classroom: A study of K-12 mathematics and science education in the United States.* Chapel Hill, NC: Horizon Research, Inc.

Whitney, L., Golez, F., Nagel, G., & Nieto, C. (2002). Listening to voices of teachers to examine the effectiveness of a teacher education program. *Action in Teacher Education*, *23*(4), 69–76.

Wilson, S. M., & Ball, D. L. (1996). Helping teachers meet the standards: New challenges for teacher educators. *Elementary School Journal*, *97*, 121-138.

Yinger, R. J., & Hendricks-Lee, M. S. (2000). The language of standards and teacher education reform. *Educational Policy*, *14*(1), 94−96.

Zimmerlin, D., & Nelson, M. (2000). The detailed analysis of a beginning teacher carrying out a traditional lesson. Journal *of Mathematical Behavior*, *18*(3), 263-279.

APPENDIX A: MATRIX

TEx Es^{TM} Standards Survey

Course Name: ______________________

* This survey contains ALL TExEs for 4-8 Mathematics. Please check off a specific learning outcome if it is believed to be covered in the course. This survey contains ALL TExES for 4-8 Mathematics. Skip over the learning outcomes that the indicated course does not address.
* If a learning outcome is checked off, please indicate what type of assessment method is being used to measure the students' understanding.
* If appropriate, please indicate your perception of the students' current understanding of each learning outcome.
* Please feel free to leave any comments in the space provided at the end of the survey.

Code	Specific Learning Outcomes	Assessment Methods	Level of Students' Understanding
111	To analyze the structure of numeration systems and the roles of place value and zero in the base ten system. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
112	To understand the relative magnitude of whole numbers, integers, rational numbers, and real numbers. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
113	To demonstrate an understanding of a variety of models for representing numbers (e.g., fraction strips, diagrams, patterns, shaded regions, number lines). □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
114	To demonstrate an understanding of equivalency among different representations of rational numbers. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
115	To select appropriate representations of real numbers (e.g., fractions, decimals, percents, roots, exponents, scientific notation) for particular situations.	□ Paper-pencil test □ Homework □ Inclass work	□ Strong □ Satisfactory □ Needs

	□ Yes □ No □ Not sure	□ Not assessed □ Other (Please specify.)	improvement □ Other (Please explain.)
116	To understand the characteristics of the set of whole numbers, integers, rational numbers, real numbers, and complex numbers (e.g., commutativity, order, closure, identity elements, inverse elements, density). □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
117	To demonstrate an understanding of how some situations that have no solution in one number system (e.g., whole numbers, integers, rational numbers) have solutions in another number system (e.g., real numbers, complex numbers). □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
121	To work proficiently with real and complex numbers and their operations. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
122	To analyze and describe relationships between number properties, operations, and algorithms for the four basic operations involving integers, rational numbers, and real numbers. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
123	To use a variety of concrete and visual representations to demonstrate the connections between operations and algorithms. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
124	To justify procedures used in algorithms for the four basic operations with integers, rational numbers, and real numbers, and analyzes error patterns that may occur in their application. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
125	To relate operations and algorithms involving numbers to algebraic procedures (e.g., adding fractions to adding rational expressions, division of integers to division of polynomials). □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)

126	To extend and generalize the operations on rationals and integers to include exponents, their properties, and their applications to the real numbers. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
131	To demonstrate an understanding of ideas from number theory (e.g., prime factorization, greatest common divisor) as they apply to whole numbers, integers, and rational numbers, and uses these ideas in problem situations. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
132	To use integers, rational numbers, and real numbers to describe and quantify phenomena such as money, length, area, volume, and density. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
133	To apply knowledge of place value and other number properties to develop techniques of mental mathematics and computational estimation. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
134	To apply knowledge of counting techniques such as permutations and combinations to quantify situations and solve problems. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
135	To apply properties of the real numbers to solve a variety of theoretical and applied problems. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
241	To use inductive reasoning to identify, extend, and create patterns using concrete models, figures, numbers, and algebraic expressions. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
242	To formulate implicit and explicit rules to describe and construct sequences verbally, numerically, graphically, and symbolically. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)

243	To make, test, validate, and use conjectures about patterns and relationships in data presented in tables, sequences, or graphs. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
244	To gives appropriate justification of the manipulation of algebraic expressions. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
245	To illustrate the concept of a function using concrete models, tables, graphs, and symbolic and verbal representations. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
246	To use transformations to illustrate properties of functions and relations and to solve problems. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
251	To demonstrate an understanding of the concept of linear function using concrete models, tables, graphs, and symbolic and verbal representations. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
252	To demonstrate an understanding of the connections among linear functions, proportions, and direct variation. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
253	To determines the linear function that best models a set of data. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
254	To analyze the relationship between a linear equation and its graph. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
255	To use linear functions, inequalities, and systems to model problems.	□ Paper-pencil test □ Homework	□ Strong □ Satisfactory

	□ Yes □ No □ Not sure	□ Inclass work □ Not assessed □ Other (Please specify.)	□ Needs improvement □ Other (Please explain.)
256	To use a variety of representations and methods (e.g., numerical methods, tables, graphs, algebraic techniques) to solve systems of linear equations and inequalities. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
257	To demonstrate an understanding of the characteristics of linear models and the advantages and disadvantages of using a linear model in a given situation. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
261	To use a variety of methods to investigate the roots (real and complex), vertex, and symmetry of a quadratic function or relation. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
262	To demonstrate an understanding of the connections among geometric, graphic, numeric, and symbolic representations of quadratic functions. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
263	To analyze data and represents and solves problems involving exponential growth and decay. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
264	To demonstrate an understanding of the connections among proportions, inverse variation, and rational functions. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
265	To understands the effects of transformations such as f($x \pm c$) on the graph of a nonlinear function f(x). □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
266	To apply properties, graphs, and applications of nonlinear functions to analyze, model, and solve	□ Paper-pencil test □ Homework	□ Strong □ Satisfactory

	problems. □ Yes □ No □ Not sure	□ Inclass work □ Not assessed □ Other (Please specify.)	□ Needs improvement □ Other (Please explain.)
267	To use a variety of representations and methods (e.g., numerical methods, tables, graphs, algebraic techniques) to solve systems of quadratic equations and inequalities. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
268	To understand how to use properties, graphs, and applications of nonlinear relations including polynomial, rational, radical, absolute value, exponential, logarithmic, trigonometric, and piecewise functions and relations to analyze, model, and solve problems. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
271	To relate topics in middle school mathematics to the concept of limit in sequences and series. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
272	To relate the concept of Satisfactory rate of change to the slope of the secant line and instantaneous rate of change to the slope of the tangent line. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
273	To relate topics in middle school mathematics to the area under a curve. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
274	To demonstrate an understanding of the use of calculus concepts to answer questions about rates of change, areas, volumes, and properties of functions and their graphs. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
381	To select and use appropriate units of measurement (e.g., temperature, money, mass, weight, area, capacity, density, percents, speed, acceleration) to quantify, compare, and communicate information. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)

382	To develop, justify, and use conversions within measurement systems. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
383	To apply dimensional analysis to derive units and formulas in a variety of situations (e.g., rates of change of one variable with respect to another) and to find and evaluate solutions to problems. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
384	To describe the precision of measurement and the effects of error on measurement. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
385	To apply the Pythagorean theorem, proportional reasoning, and right triangle trigonometry to solve measurement problems. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
391	To understand concepts and properties of points, lines, planes, angles, lengths, and distances. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
392	To analyze and apply the properties of parallel and perpendicular lines. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
393	To use the properties of congruent triangles to explore geometric relationships and prove theorems. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
394	To describe and justify geometric constructions made using a compass and straight edge and other appropriate technologies. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)

395	To apply knowledge of the axiomatic structure of Euclidean geometry to justify and prove theorems. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
310.1	To use and understand the development of formulas to find lengths, perimeters, areas, and volumes of basic geometric figures. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
310.2	To apply relationships among similar figures, scale, and proportion and analyzes how changes in scale affect area and volume measurements. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
310.3	To use a variety of representations (e.g., numeric, verbal, graphic, symbolic) to analyze and solve problems involving two- and three-dimensional figures such as circles, triangles, polygons, cylinders, prisms, and spheres. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
310.4	To analyze the relationship among three-dimensional figures and related two-dimensional representations (e.g., projections, cross-sections, nets) and use these representations to solve problems. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
311.1	To describe and justify geometric constructions made using a reflection device and other appropriate technologies. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
311.2	To use translations, reflections, glide-reflections, and rotations to demonstrate congruence and to explore the symmetries of figures. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
311.3	To use dilations (expansions and contractions) to illustrate similar figures and proportionality. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please	□ Strong □ Satisfactory □ Needs improvement □ Other (Please

		specify.)	explain.)
311.4	To use symmetry to describe tessellations and show how they can be used to illustrate geometric concepts, properties, and relationships. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
311.5	To apply concepts and properties of slope, midpoint, parallelism, and distance in the coordinate plane to explore properties of geometric figures and solve problems. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
311.6	To apply transformations in the coordinate plane. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
311.7	To use the unit circle in the coordinate plane to explore properties of trigonometric functions. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
412.1	To organize and display data in a variety of formats (e.g., tables, frequency distributions, stem-and-leaf plots, box-and-whisker plots, histograms, pie charts). □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
412.2	To apply concepts of center, spread, shape, and skewness to describe a data distribution. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
412.3	To support arguments, make predictions, and draw conclusions using summary statistics and graphs to analyze and interpret one-variable data. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
412.4	To demonstrate an understanding of measures of central tendency (e.g., mean, median, mode) and dispersion (e.g., range, interquartile range, variance, standard deviation). □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)

412.5	To analyze connections among concepts of center and spread, data clusters and gaps, data outliers, and measures of central tendency and dispersion. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
412.6	To calculate and interpret percentiles and quartiles. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
413.1	To explore concepts of probability through data collection, experiments, and simulations. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
413.2	To use the concepts and principles of probability to describe the outcome of simple and compound events. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
413.3	To generate, simulate, and use probability models to represent a situation. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
413.4	To determine probabilities by constructing sample spaces to model situations. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
413.5	To solve a variety of probability problems using combinations, permutations, and geometric probability (i.e., probability as the ratio of two areas). □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
413.6	To use the binomial, geometric, and normal distributions to solve problems. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please	□ Strong □ Satisfactory □ Needs improvement □ Other (Please

		specify.)	explain.)
414.1	To apply knowledge of designing, conducting, analyzing, and interpreting statistical experiments to investigate real-world problems. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
414.2	To demonstrate an understanding of random samples, sample statistics, and the relationship between sample size and confidence intervals. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
414.3	To apply knowledge of the use of probability to make observations and draw conclusions from single variable data and to describe the level of confidence in the conclusion. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
414.4	To makes inferences about a population using binomial, normal, and geometric distributions. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
414.5	To demonstrate an understanding of the use of techniques such as scatter plots, regression lines, correlation coefficients, and residual analysis to explore bivariate data and to make and evaluate predictions. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
515.1	To demonstrate an understanding of proof, including indirect proof, in mathematics. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
515.2	To apply correct mathematical reasoning to derive valid conclusions from a set of premises. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
515.3	To demonstrate an understanding of the use of inductive reasoning to make conjectures and deductive methods to evaluate the validity of conjectures. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please	□ Strong □ Satisfactory □ Needs improvement □ Other (Please

		specify.)	explain.)
515.4	To apply knowledge of the use of formal and informal reasoning to explore, investigate, and justify mathematical ideas. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
515.5	To recognize that a mathematical problem can be solved in a variety of ways and selects an appropriate strategy for a given problem. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
515.6	To evaluate the reasonableness of a solution to a given problem. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
515.7	To apply content knowledge to develop a mathematical model of a real world situation and analyzes and evaluates how well the model represents the situation. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
515.8	To demonstrate an understanding of estimation and evaluates its appropriate uses. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
516.1	To recognize and use multiple representations of a mathematical concept (e.g., a point and its coordinates, the area of circle as a quadratic function in *r*, probability as the ratio of two areas). □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
516.2	To use mathematics to model and solve problems in other disciplines, such as art, music, science, social science, and business. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
516.3	To expresses mathematical statements using developmentally appropriate language, standard English, mathematical language, and symbolic mathematics. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)

516.4	To communicate mathematical ideas using a variety of representations (e.g., numeric, verbal, graphic, pictorial, symbolic, concrete). □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
516.5	To demonstrate an understanding of the use of visual media such as graphs, tables, diagrams, and animations to communicate mathematical information. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
516.6	To use the language of mathematics as a precise means of expressing mathematical ideas. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
516.7	To understands the structural properties common to the mathematical disciplines. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
617.1	To apply theories and principles of learning mathematics to plan appropriate instructional activities for all students. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
617.2	To understand how students differ in their approaches to learning mathematics with regards to diversity. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
617.3	To use students' prior mathematical knowledge to build conceptual links to new knowledge and plans instruction that builds on students' strengths and addresses students' needs. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
617.4	To understand how learning may be assisted through the use of mathematics manipulatives and technological tools. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)

617.5	To understand how to motivate students and actively engage them in the learning process by using a variety of interesting, challenging, and worthwhile mathematical tasks in individual, small-group, and large-group settings. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
617.6	To understand how to provide instruction along a continuum from concrete to abstract. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
617.7	To recognize the implications of current trends and research in mathematics and mathematics education. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
618.1	To demonstrate an understanding of a variety of instructional methods, tools, and tasks that promote students' ability to do mathematics described in the TEKS. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
618.2	To understand planning strategies for developing mathematical instruction as a discipline of interconnected concepts and procedures. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
618.3	To develop clear learning goals to plan, deliver, assess, and reevaluate instruction based on the TEKS. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
618.4	To understand procedures for developing instruction that establishes transitions between concrete, symbolic, and abstract representations of mathematical knowledge. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
618.5	To apply knowledge of a variety of instructional delivery methods, such as individual, structured small-group, and large-group formats. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)

618.6	To understand how to create a learning environment that provides all students, including English Language Learners, with opportunities to develop and improve mathematical skills and procedures. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
618.7	To demonstrate an understanding of a variety of questioning strategies to encourage mathematical discourse and to help students analyze and evaluate their mathematical thinking. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
618.8	To understand how technological tools and manipulatives can be used appropriately to assist students in developing, comprehending, and applying mathematical concepts. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
618.9	To understand how to relate mathematics to students' lives and a variety of careers and professions. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
619.1	To demonstrate an understanding of the purpose, characteristics, and uses of various assessments in mathematics, including formative and summative assessments. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
619.2	To understand how to select and develop assessments that are consistent with what is taught and how it is taught. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
619.3	To demonstrate an understanding of how to develop a variety of assessments and scoring procedures consisting of worthwhile tasks that assess mathematical understanding, common misconceptions, and error patterns. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)
619.4	To understand how to evaluate a variety of assessment methods and materials for reliability, validity, absence of bias, clarity of language, and appropriateness of	□ Paper-pencil test □ Homework □ Inclass work	□ Strong □ Satisfactory □ Needs

	mathematical level. □ Yes □ No □ Not sure	□ Not assessed □ Other (Please specify.)	improvement □ Other (Please explain.)
619.5	To understand the relationship between assessment and instruction and know how to evaluate assessment results to design, monitor, and modify instruction to improve mathematical learning for all students, including English Language Learners. □ Yes □ No □ Not sure	□ Paper-pencil test □ Homework □ Inclass work □ Not assessed □ Other (Please specify.)	□ Strong □ Satisfactory □ Needs improvement □ Other (Please explain.)

Any comments are welcome here:

APPENDIX B: QUEST ANONYMOUS SURVEY

QUEST Anonymous Survey

Name: (This is an anonymous survey. Please do not include your name or anything that may indicate your identity anywhere on the survey.)

Please identify your level: I am currently in QUEST 1, QUEST 2 or QUEST 3 [drop down menu]

I am a [drop down menu: undergraduate, M.Ed student, NDO student, PB student]

I am seeking: [4-8 English/Language Arts and Reading, Mathematics, Science, and Social Studies [drop down menu] – this response should send the candidate to a survey specific to his or her certification level.

If you have taken or are taking the mathematics assessments, please indicate the 4-digit code that you used: ______

Directions:

- As part of our efforts to improve the QUEST program, we value your recommendations.
- Please note that this survey is not meant to be an evaluation of instructors and their teaching.
- Please feel free to elaborate your responses in the provided space.

1a. How well do you feel that your program prepared you for the following TExES standards? [For math 4 – 8]

The Standards	No Coverage	Limited Coverage	Moderate Coverage	In-depth Coverage
Number Concepts	○	○	○	○
Patterns and Algebra	○	○	○	○
Geometry and Measurement	○	○	○	○
Probability and Statistics	○	○	○	○

Mathematical Processes and Perspectives	○	○	○	○
Mathematical Learning, Instruction and Assessment	○	○	○	○
The Texas Essential Knowledge and Skills (TEKS) in mathematics 4 – 8	○	○	○	○

Please elaborate more specifically if necessary:

1b. How well do you feel that your program prepared you for the following TExES standards? [For English Language Arts and Reading 4 – 8]

The Standards	**No Coverage**	**Limited Coverage**	**Moderate Coverage**	**In-depth Coverage**
Oral Language	○	○	○	○
Foundations of Reading	○	○	○	○
Word Analysis Skills and Reading Fluency	○	○	○	○
Reading Fluency	○	○	○	○
Assessment of Developing Literacy	○	○	○	○
Reading Comprehension	○	○	○	○
Written Language	○	○	○	○
Study and Inquiry Skills	○	○	○	○
Viewing and Representing	○	○	○	○
The Texas Essential Knowledge and Skills (TEKS) in English language arts and reading 4 – 8	○	○	○	○

Please elaborate more specifically if necessary:

1c. How well do you feel that your program prepared you for the following TExES standards? [For Science 4 – 8]

The Standards	No Coverage	Limited Coverage	Moderate Coverage	In-depth Coverage
Scientific Inquiry and Processes	○	○	○	○
Physical Science	○	○	○	○
Life Science	○	○	○	○
Earth and Space Science	○	○	○	○
Science Learning, Instruction, and Assessment	○	○	○	○
The Texas Essential Knowledge and Skills (TEKS) in science 4 – 8	○	○	○	○

Please elaborate more specifically if necessary:

1d. How well do you feel that your program prepared you for the following TExES standards?

The Standards	**No Coverage**	**Limited Coverage**	**Moderate Coverage**	**In-depth Coverage**
History	○	○	○	○
Geography	○	○	○	○
Economics	○	○	○	○
Government	○	○	○	○
Citizenship	○	○	○	○
Culture	○	○	○	○
Science, Technology and Society	○	○	○	○
Curriculum, Instruction and Assessment	○	○	○	○
The Texas Essential Knowledge and Skills (TEKS) in social science	○	○	○	○

<u>Please elaborate more specifically if necessary:</u>

2. How well did your program prepare you for the following five process standards of the National Council of Teacher of Mathematics?

The Standards	**No Coverage**	**Limited Coverage**	**Moderate Coverage**	**In-depth Coverage**
Problem Solving	○	○	○	○
Reasoning	○	○	○	○
Communication	○	○	○	○
Connections	○	○	○	○
Representation	○	○	○	○

<u>Please elaborate more specifically if necessary:</u>

Directions: Please mark the option corresponding to your level of agreement or disagreement with each item.

3. The program provided me opportunities to build an adequate foundation in mathematics necessary to be an effective mathematics teacher.

STRONGLY DISAGREE	SOMEWHAT DISAGREE	NEITHER DISAGREE/AGREE	SOMEWHAT AGREE	STRONGLY AGREE
○	○	○	○	○

Comments:

4. The program provided me opportunities to build an adequate foundation in the teaching knowledge necessary to become an effective mathematics teacher.

STRONGLY DISAGREE	SOMEWHAT DISAGREE	NEITHER DISAGREE/AGREE	SOMEWHAT AGREE	STRONGLY AGREE
○	○	○	○	○

Comments:

6. How satisfied are you about the <u>mathematics education courses</u>?

NOT SATISFYING AT ALL	SOMEWHAT UNSATISFYING	NOT SURE	MODERATELY SATISFYING	VERY SATISFYING
○	○	○	○	○

Comments:

7. Which <u>mathematics education courses</u> do you think were important (or unimportant) in your preparation to be a math teacher?

8. How satisfied are you about the <u>field experiences</u> of the QUEST program?

NOT SATISFYING AT ALL	SOMEWHAT UNSATISFYING	NOT SURE	MODERATELY SATISFYING	VERY SATISFYING
○	○	○	○	○

Comments:

9. How satisfied are you about the general mathematics courses?

NOT SATISFYING AT ALL	SOMEWHAT UNSATISFYING	NOT SURE	MODERATELY SATISFYING	VERY SATISFYING
○	○	○	○	○

10. Which mathematics courses do you think were important (or unimportant) in your preparation to be a math teacher?

11. How satisfied are you about the overall program coursework in the 4-8 mathematics teacher preparation program?

NOT SATISFYING AT ALL	SOMEWHAT UNSATISFYING	NOT SURE	MODERATELY SATISFYING	VERY SATISFYING
○	○	○	○	○

Comments:

Please feel free to elaborate below more specifically what you found satisfying or unsatisfying about the program.

11. What would you change about the program to improve the mathematics education component of QUEST, such as course sequencing, program requirements, teaching practices, etc.? Your recommendations are very important for program improvement.