INITIAL FULL-TIME CLASSROOM TEACHING EXPERIENCES FOR INTERNS AND STUDENT TEACHERS: FACTORS CONTRIBUTING TO THEIR MATHEMATICS TEACHING DEVELOPMENT

A Dissertation

by

DIANA LYNNE PICCOLO

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2008

Major Subject: Curriculum & Instruction

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ABSTRACT

Initial Full-time Classroom Experiences for Interns and Student Teachers: Factors Contributing to Their Mathematics Teaching Development. (May 2008)

Diana Lynne Piccolo, B.S., Texas A&M University; M.S., Texas A&M University

Chair of Advisory Committee: Dr. Robert M. Capraro

In the Teaching Principle (National Council of Teachers of Mathematics [NCTM], 2000), it explained that development and utilization of pedagogical content knowledge required teachers to continually increase their knowledges of mathematics content and pedagogy. This study researched the amalgamation of multi-faceted factors and inter-relatedness of pedagogical content knowledge (PCK), content knowledge for teaching mathematics (CKTM), and mentoring support perceptions throughout elementary and middle level student teachers' and interns' initial full-time teaching experiences.

In the first article 13 elementary and seven middle grade student teachers' are examined based on differences between pedagogical content knowledge and content knowledge for teaching mathematics. Standardized difference scores were calculated and compared using multivariate contrasts on certification level. Results showed statistically significant differences ($p < .01$) on all three CKTM domains but no statistically significant differences were found on any of the five Classroom Observation and Assessment for Teachers (COPAT) domains. Both groups had the highest mean difference in the CKTM number/concept domain. COPAT results showed middle grade level pre-service teachers primarily had all positive mean differences, in comparison to the elementary level pre-service teachers, which had all negative mean differences.

In the second article the mathematics mentoring support perceptions of 11 first year teachers who participated in a year-long urban internship program were examined. Semi-structured interviews revealed that district and grade level campus mentors provided the most mathematics instruction and pedagogically-based support to both groups of interns. Middle school level interns relied more on their team of mathematics teachers and elementary level interns received more mathematical content support from their district mentor than did middle level interns. Pedagogical support was greatest in the areas of lesson design and implementation of classroom management strategies.

In the third article 14 elementary and six middle level student teachers were observed and interviewed on general and content-specific pedagogical skills and perceptions. Results indicated both groups of student teachers perceived themselves as most competent in having lesson plans ready, routines evident, and utilizing student-centered instruction. Conversely, both groups felt least competent in getting students on task quickly, using a variety of teaching strategies, using critical thinking skills, and handling inappropriate behavior effectively.

DEDICATION

To my husband and daughters, for their patience and understanding.

To my father, for his love and support.

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CHAPTER I

INTRODUCTION

The purpose of this dissertation is to present in manuscript format three articles and a research brief (as introduction) that emerged as a result of 1) observing, assessing and interviewing 20 student teachers to understand their pedagogical and content knowledge for teaching mathematics development and 2) interviewing 11 interns to understand perceptions of their mentoring support systems and factors that influenced their ability to teach mathematics. Purposes of each article include: 1) an examination of differences and relationships of pedagogical content knowledge factors and content knowledge for teaching mathematics among elementary and middle level student teachers, 2) an investigation of mentoring support perceptions and specific pedagogical factors that influenced the ability of first year interns to teach mathematics, and 3) an examination of observational and self-perceptions on student teachers' general and content-specific pedagogical development.

Rationale for Study

The rationale for this research focused on elementary and middle level student teachers and interns and how factors such as, mentoring support perceptions, pedagogical content knowledge and content knowledge for teaching mathematics developed throughout their initial full-time teaching experiences. Use of multiple

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This dissertation follows the style of *Journal of Educational Research.*

groups, measures, and research designs, were employed to gain the most complete and comprehensive understanding of how these three factors influenced student teachers' and interns' ability to teach mathematics.

This study was organized into five chapters, follows style guidelines of the *Publication Manual of the American Psychological Association, Fifth Edition* and was written and submitted to journals for scholarly publication. This chapter, Chapter I, will introduce the study and outline the framework for chapters II through IV. Chapter V will present a discussion of research implications and contributions the articles will provide to the field of mathematics education. References, appendices, and vita will follow chapter five.

Research Questions

The purpose of the study in Chapter II examined and assessed differences and relationships of pedagogical content knowledge factors and content knowledge for teaching mathematics and addressed the following research questions:

(1) What trends or factors emerged between pedagogical content knowledge domains situated in a mathematics classroom and content knowledge for teaching mathematics domains, and

(2) How did elementary and middle grade level pre-service teachers differ between PCK and CKTM mathematics domains?

The purpose of the study in Chapter III examined the mathematics mentoring support perceptions of first year teachers who participated in a year-long urban internship program and addressed the following research questions:

(1) How did various roles of mentors help develop urban interns' ability to teach mathematics?

(2) What specific teaching skills, factors, and pedagogical behaviors helped or hindered urban interns' ability to teach mathematics?

The purpose of the study presented in Chapter IV compared general and content-specific pedagogical skills of elementary and middle level student teachers with the researcher's external observations and addressed the following research questions,

(1) What trends in general and content-specific pedagogical behaviors, resulted in elementary and middle level student teachers' pedagogical development such as: a) instructional preparedness, b) instructional environment/classroom management, c) format and structure of instructional content delivery, d) instructional monitoring, and e) motivation and feedback, in teaching mathematics?

(2) What self perceptions of general and content-specific pedagogical skills did student teachers possess?

(3) What were the most important differences between general and content-specific teaching behaviors evident between the researchers' external observations and student teachers' self perceptions?

Understanding factors pertaining to pedagogical and content knowledge for teaching mathematics are critical for preparing and supporting pre-service teachers throughout their initial full-time teaching experience. The following review of research delineates the importance of continued research and focus in these areas of teacher preparation.

Views of Content and Pedagogical Knowledges for Teaching Mathematics

The ability to teach mathematics content is influenced by both general pedagogy, pedagogical content knowledge and mathematical content knowledge. Shulman (1987) stated several categories of teacher knowledge, including *content* knowledge, *general pedagogical* knowledge, and *pedagogical content* knowledge. He described content knowledge as the knowledge, understanding, skills, and dispositions that students learn. General pedagogy knowledge is described as broad teaching strategies, such as classroom management and organization and pedagogical content knowledge as the "blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (p. 8). Mathematics education researchers have expounded on several of Shulman's ideas and focused on specific pedagogies and content knowledge needed for teaching mathematics.

Research is replete with strategies and methods pertaining to pedagogical content knowledge and content knowledge for teaching mathematics (Ball, Bass, & Hill, 2004; Borko & Livingston, 1989; Leinhardt & Smith, 1985; Tirosh, 2000; Wilson, Floden & Ferrini-Mundy, 2002). The National Council of Teachers of Mathematics (NCTM, 2000) outlined in the Teaching Principle that teachers continue to develop their pedagogical content knowledge to further increase their knowledge about mathematical content and pedagogy. Ball and Bass (2000) discuss the importance of interweaving content and pedagogy, despite the gap that exists between how to effectively organize and develop teachers' knowledge in these two areas.

General pedagogy skills used in planning and structuring a mathematics lesson include managing the classroom, organizing activities, lesson planning, motivating students, and assessing mathematics content (Fennema & Franke, 1992; Interstate New Teacher Assessment and Support Consortium, 1992). The Interstate New Teacher Assessment and Support Consortium (INTASC) Standards were developed to reflect what beginning teachers needed to know in teaching. They included both general and content pedagogy skills, such as planning lessons and activities that meet the needs of varied learners and understanding subject matter concepts. Leinhardt and Smith (1985) described this knowledge as "lesson structure knowledge" that is separate from content knowledge. Components of this knowledge included skills needed to plan a lesson and transitions from one part of the lesson to another. If general pedagogy skills are planning and preparation of mathematics teaching, then pedagogical content knowledge is the inclusion of that pedagogy into the actual teaching of mathematical content. Even (1993) stated that pedagogical decisions, such as designing and planning activities, are based partially on content knowledge.

Multiple views have been presented on how mathematical content knowledge should be taught in order to ensure quality instruction in the classroom (Ball, Hill & Bass, 2005; Eisenhart, Borko, Underhill, Brown, Jones, & Agard, 1993; Leindhardt & Smith, 1985; Ma, 1999; NCTM, 2000; Schoenfeld, 1998; Sherin, 2002). Ma (1999) found that mathematical content should be taught as a developmental-coherent whole in which teachers needed a deep, vast, and thorough understanding of that knowledge. Leinhardt and Smith (1985) showed that subject matter knowledge needed in mathematics instruction included “concepts, algorithmic operations, the connections among different algorithmic procedures, the subset of the number system being drawn upon, the understanding of types of student errors, and curriculum presentation” (p. 247). The understanding of this content knowledge was depicted through a combination of semantic nets, planning nets, and flow charts. Another view of mathematics content knowledge is ‘common’ and ‘specialized’ knowledge (Ball, Bass, & Hill, 2004). ‘Common’ knowledge is the essential algorithmic and procedural knowledge necessary for computing mathematical solutions. ‘Specialized’ knowledge is the skills, procedures, and competencies needed for teaching mathematics to students. Mathematics teachers need both types of knowledge to teach effectively so they can “unpack” mathematical ideas and procedures for their students (Ball, 2001).

Pedagogical content knowledge (PCK) is a nexus of both content and pedagogy into a form of knowledge that comprises representations of analogies, illustrations, examples, explanations, and demonstrations so that the content is understandable to students. Ball and Bass (2000) stated that pedagogical content knowledge is “representations of particular topics and how students tend to use them . . . it is the close interweaving of subject matter and pedagogy in teaching” (p. 87). The development of teachers’ pedagogical content knowledge is influenced by several factors, beginning with content knowledge learned during teacher preparation program and initial teaching experiences (Capraro, Capraro, Parker, Kulm, & Raulerson, 2005). Students need a combination of content knowledge, teaching for understanding, and curriculum to gain a more of a conceptual understanding of mathematics (An, Kulm, & Wu, 2004).

The framework for effective mathematics teaching comprises these three components: general pedagogy, content knowledge for teaching mathematics, and pedagogical content knowledge. Nevertheless, all pedagogical competencies and understandings are based upon having a deep, vast, and thorough understanding of mathematical content. The inter-relatedness of these components and how they influence mathematics teaching and learning makes this a multifaceted topic for contemporary mathematics educators and researchers.

However, the ability of these three components is influenced by the mentoring support that pre-service teachers, such as interns, receive throughout their initial full-time teaching experiences. Austin and Fraser-Adber (1995) reported that mentoring urban interns in mathematics classroom needs to become a central part of teacher education. Unfortunately, many mentors do not have the skills, training, or education to effectively mentor beginning mathematics teachers (Hudson & Peard, 2005). Factors and implications of educating, mentoring, and retaining mathematics interns in urban schools needs to be better understood.

Interactions of elementary and middle grade level pre-service teachers with mentors, students, parents, administrators and other educators throughout their initial teaching experience resulted in a culmination between both content knowledge for teaching mathematics (CKTM) and pedagogical content knowledge (PCK) factors. This study examined these initial experiences within classroom observations, between researcher and pre-service teacher interactions, and through pre-service teacher self-reports and assessments.

CHAPTER II

EXPANDING THE THEORY OF PCK AND CKTM FOR ELEMENTARY AND MIDDLE PRE-SERVICE TEACHERS

Preparing pre-service teachers to teach mathematics in an ever-demanding workplace has been identified as an urgent need by mathematical educators (Ball & Wilson, 1990; Ma, 1999; RAND Mathematics Study Panel, 2003; Sherin, 1996). Pre-service teachers need support and guidance to develop pedagogical content knowledge skills and content knowledge for teaching mathematics in order to educate tomorrow's generation of Americans. They need to know mathematical knowledge required for teaching, in conjunction with salient pedagogy.

The purpose of this study was to examine and assess differences and relationships of pedagogical content knowledge factors and content knowledge for teaching mathematics among 20 pre-service teachers throughout their 12 weeks of student teaching. This study will help researchers to better understand the specific domain effects of content knowledge for teaching mathematics with pedagogical content knowledge development among pre-service teachers. The significance of this study was to further develop research on improving and understanding how pedagogical content knowledge factors and content knowledge for teaching mathematics develops within novice teachers, such as pre-service teachers (Capraro, Capraro, Parker, Kulm, & Raulerson, 2005). Two questions frame this study, (1) what trends or factors emerged between pedagogical content knowledge domains situated in mathematics education and content knowledge for teaching mathematics domains? and (2) How did elementary and middle grade level pre-service teachers differ between pedagogy content knowledge and content knowledge for teaching mathematics domains?

Introduction

The Department of Education Report stated current research needed more studies that 1) related subject matter, pedagogy, and clinical experiences and their effects on teaching practices; 2) developed measures of what teachers' actually learn through their field experiences and 3) collected and assessed measures of teacher learning, knowledge and skill without solely relying on self-reports or ratings by teachers and administrators (Wilson, Floden & Mundy, 2001).

The mathematical knowledge needed for teaching, the subject of 20 years of research, is still not well understood (Ball, 1996; Hill & Ball, 2004; Ma, 1999). Continued research is essential to disentangle the complexities of algorithmic-only mathematical understandings, and processes for making mathematical ideas accessible at early levels of mathematical learning. By understanding the complexities of algorithmic-only understandings, it will help to explicate the relative importance of basic skills in mathematics relative to each grade level. Making mathematical ideas accessible may improve both the teachers' level of mathematical conceptualization and student conceptual development that serves as foundational for future mathematics understandings (Ball, Hill, & Bass, 2005). Thus, this research has indicated the importance of understanding teachers' knowledge of mathematics for developing the standards of mathematics instruction (Ball, 1991; Hill & Ball, 2004; Ma, 1999; Sherin, 1996). Therefore, teacher educators need to understand more about the mathematical knowledge required for teaching (Ball, Lubienski, & Mewborn, 2001; RAND Mathematics Study Panel, 2003), especially for pre-service teachers.

Contemporary Views of Content and Pedagogical Knowledges

Views of Content Knowledge in Mathematics

Mathematics educators have recognized that a solid foundation and understanding of mathematical content knowledge is an essential component for effective teaching and student learning (Ball, Hill & Bass, 2005; Eisenhart et al., 1993; Leindhardt & Smith, 1985; Ma, 1999; NCTM, 2000; Schoenfeld, 1998; Sherin, 1996). Since Begle's (1979) report on the negative relationship between the number of mathematics courses completed by pre-service teachers and their subsequent students' mathematics achievement in the classroom, researchers have been striving to better understand what content is critical for teachers to know and the best method of delivery to students. The mathematical knowledge teachers bring to their classrooms and how this content knowledge is taught to students must be refined (Sherin, 2002). There are several views of how mathematical content knowledge should be refined in the context of preparing mathematics teachers for quality instruction in the classroom.

Mathematical content should be taught as a developmental-coherent whole. Ma (1999) sparked interest when she compared Chinese and U.S. elementary teachers' mathematical content knowledge and found teachers needed a deep, vast, and thorough understanding of that knowledge. With regard to pre-service teachers' mathematics knowledge, "deep" refers to understandings that connect mathematics with ideas of greater conceptual power; "vast" refers to connecting topics of similar conceptual insight; “thoroughness” refers to the capacity to inter-weave parts of the subject into a meaningful whole (Capraro et al., 2005). Therefore, mathematical knowledge should be inter-connected and longitudinally coherent (Ball, Bass, & Hill, 2004).

There are many areas of mathematics content knowledge and skills involved in teaching mathematics. Leinhardt and Smith (1985) discussed two areas of content knowledge, lesson structure and subject matter knowledge, needed for expertise in mathematics instruction. This subject matter knowledge used to describe content knowledge included “concepts, algorithmic operations, the connections among different algorithmic procedures, the subset of the number system being drawn upon, the understanding of types of student errors, and curriculum presentation” (Leinhardt & Smith, 1985, p. 247). The inter-connectedness of lesson structure and content knowledge was depicted through a combination of semantic nets, planning nets, and flow charts.

When content knowledge is examined as it is used in the classroom it can be disaggregated into two component parts (Ball, Bass, & Hill, 2004). They defined the first component part as ‘common’ knowledge and the second component part as ‘specialized’ knowledge. ‘Common’ knowledge is the essential algorithmic and procedural knowledge necessary for computing mathematical solutions. ‘Specialized’ knowledge is the skills, procedures, and competencies needed for teaching mathematics to students. Mathematics teachers need both types of knowledge to teach effectively so they can “unpack” mathematical ideas and procedures for their students (Ball, 2001).

Mathematics teachers, especially pre-service teachers, need a well developed, thorough, and flexible understanding of mathematical content knowledge before entering the classroom. Unfortunately, knowing content is not sufficient to ensure quality mathematics instruction. Relying on mathematical content knowledge alone cannot provide conceptual understandings without some level of pedagogical competence.

General Pedagogy Skills

Pedagogical knowledge that is learned and developed throughout a teachers' career enables them to 1) understand how students learn, 2) become proficient in using a wide variety of different teaching techniques and instructional materials, and 3) organize and manage the classroom. Pre-service teachers need a solid understanding of how knowledge is developed through carefully chosen and implemented pedagogical strategies (INTASC, 1992). An example of general pedagogy skills that teachers should demonstrate in the classroom include: 1) instructional preparedness, 2) classroom management, 3) instructional strategies for conducting lessons and creating learning environments, 4) providing instructional monitoring of student work and engagement in the lesson, and 5) providing instructional motivation and feedback from students before, during, and after the lesson (Borko & Putnam, 1996; INTASC, 1992). However, general pedagogy skills and techniques are not sufficient to ensure mathematics learning for students.

Content-Specific Pedagogy

Prior research has indicated that teachers' subject-matter knowledge and its relationship with pedagogical knowledge is still not well known (Even, 1993). Pedagogical content knowledge (PCK) is the domain-specific knowledge of teaching that combines both content and pedagogy and the relationship and interdependence between the two (Shulman, 1987). Pedagogical content knowledge is a "kind of content knowledge that goes beyond just knowing the subject matter per se but more a type of subject matter *for teaching*" (Shulman, 1986, p. 9). The combined mastery of content knowledge and pedagogical knowledge can result in an inter-related form of knowledge that makes use of representations including analogies, illustrations, examples, explanations, and demonstrations so that the content is understandable to students.

One focus of the National Council of Teachers of Mathematics (NCTM, 2000) is the development and utilization of pedagogical content knowledge within mathematics education. The NCTM Standards provide an outline of the essential mathematical knowledge and skills that students should learn from Pre-K through grade 12. It also provides teachers with pedagogical strategies and resources to further develop their teaching.

Methodology

Research Questions

While CKTM and PCK are important topics, there are many sub-factors that account for proficiency in both of these areas. However, the areas of interest for this study are narrowly defined to facilitate precise measurements. The content domains of geometry, number/concept, and algebra are measured using the CKTM instrument (Hill, 2004) and the pedagogical content knowledge domains are measured using the Classroom Observation and Assessment for Teachers (COPAT) instrument. The following research questions examined, (1) what trends or factors emerged between pedagogical content knowledge domains situated in a mathematics classroom and content knowledge for teaching mathematics domains, and (2) How did elementary and middle grade level pre-service teachers differ between PCK and CKTM mathematics domains?

Participants

This study was conducted by observing and assessing thirteen elementary grade level and seven middle grade level pre-service teachers (n = 20) throughout their twelve weeks of student teaching (i.e. teacher preparation experience). Differences examined between each group (i.e. elementary and middle grade pre-service teachers) were the amount of time spent teaching mathematics, and their pedagogical content knowledge and content knowledge for teaching mathematics developmental effects throughout 12 weeks of student teaching. Using each participant's American College Testing (ACT) entrance exam or Scholastic Aptitude Test (SAT) score, grade point average, number of mathematics and mathematics education courses taken, and any prior teaching experience, the researcher controlled for prior performance.

Instrumentation

One purpose of the Learning Mathematics for Teaching (LMT) project (Ball, 2005) was to develop an assessment of teachers' mathematics knowledge. The Content Knowledge for Teaching Mathematics (CKTM) instrument had three mathematical content domains: a) geometry, b) number concepts and operations, and c) patterns, functions, and algebra (See Appendix A for a sample of released CKTM items). In a multi-step test construction process, the authors designed an instrument, implemented a pilot study, assessed and revised test items, re-formulated the instrument and repeated as necessary. Validity and reliability estimates were considered throughout the process (Hill & Ball, 2004). Instrumentation threat is an important consideration whenever there is a pre and post test and test items are different. The instrumentation threat was controlled by: a) using parallel forms of the instrument (Hill & Ball, 2004); b) using a similar population; c) receiving training from the original test designers and d) receiving on-going technical support. In this study, the Cronbach's alpha reliability estimates for elementary pre- and post tests were 0.86 and 0.79 and for middle pre- and post tests were 0.63 and 0.70, respectively.

The Classroom Observation and Performance Assessment for Teachers (COPAT)©, was used to observe and assess teacher performance and pedagogical content knowledge development. The five domains were: 1) instructional preparedness, 2) instructional environment/management, 3) instructional lesson, 4) instructional monitoring, and 5) instructional motivation and feedback, each designed using the INTASC Pedagogy Standards (1992), North Carolina Teacher Performance Appraisal System, and the Charlotte Danielson frameworks for instruction (1996). The instrumentation threat was controlled by: a) conducting a pilot study; b) using a similar sample of participants; c) receiving training from the COPAT test designer and d) receiving on-going technical support. The twenty student teachers were rated on their pedagogical preparedness using a scale from 1-10. The scales ranged from: 1-3 indicated inadequate preparedness, 4-6 indicated acceptable preparedness, 7-9 indicated commendable preparedness, and 10 indicated outstanding preparedness. Pre-service teachers in this study typically received a rating from 3 (inadequate) to 8 (commendable). The combined pre and post test Cronbach's alpha reliability estimates for elementary and middle grade were 0.89 and 0.90, respectively.

Research Design

A quasi-experimental research design was chosen for this study because random assignment to elementary (K-4) or middle grade (5-8) pre-service teaching assignments could not be implemented. Various levels of quasi-experimental design exist and the introduction of design elements can improve the quality of inferences. Because various design differences are found in the literature with accompanying levels of quality, this study employed a quasi-experimental design using multiple design elements, such as untreated comparison groups with repeated dependent pretest and posttest samples and observations to "aid in causal inference and to help reduce the likelihood of internal validity threats" (Shadish, Cook, & Campbell, 2002, p. 156) (See Figure 1).

	Pre_{CKTM}	$\text{Pre}_{\text{COPAT}}$	$\text{Pre}_{\text{INTASC*}}$	$\text{Pre}_{\text{INTASC**}}$	$\text{Post}_{\text{COPAT}}$	$\text{Post}_{\text{INTASC*}}$	$\text{Post}_{\text{INTASC**}}$	$\text{Post}_{\text{CKTM}}$	$\text{Post}_{\text{interview}}$
Elem.	X_1	O_1	X_1	X_1	O_2	X_2	X_2	X_2	O_2
Middle	X_1	O_1	X_1	X_1	O_2	X_2	X_2	X_2	O_2

FIGURE 1. Untreated comparison groups with repeated dependent pretest and posttest samples (cf. Shadish, Cook, & Campbell, 2002)
Note. Dashed line indicates nonrandom assignment;*INTASC student teachers;**INTASC cooperating teachers.

The Content Knowledge for Teaching Mathematics (CKTM) survey instrument was administered to pre-service teachers 1-2 weeks before and after their student teaching experience. Both tests consisted of 3 mathematics content domains: (1) geometry, (2) number and concepts and (3) algebra. Parallel forms (pre and post) of the CKTM survey (Hill, 2004) was administered to both elementary and middle grades pre-service teachers. The elementary version of the CKTM instrument consisted of 23 geometry, 16 number and concept, and 25 algebra *pre*test items (n = 64) and 19 geometry, 24 number and concept, and 29 algebra *post*test items (n = 72). The middle grades version of the CKTM instrument consisted of 23 geometry, 21 number and concept, and 27 algebra *pre*test items (n = 71) and 19 geometry, 17 number and concept, and 20 algebra *post*test items (n = 56).

A comparison of the questions within domains from both the elementary and middle level pr*e*test surveys found that: a) all of the geometry items were the same; b) none of the number and concept items were the same; and c) three algebra items were the same. A comparison of the elementary and middle level pos*t*test survey found that a) as with the pre-test all the geometry items were the same; b) one of the number and concept items was the same; and c) two algebra items were the same.

The COPAT instrument that measured pedagogy content knowledge, was administered immediately following the classroom observations. It was used to collect baseline pedagogical data during the 5th and 6^{th} weeks which represented the inception of the pre-service teachers' full time teaching responsibilities. The post observations were conducted during the 11th and12^{th} weeks of student teaching which represented the final two weeks of the pre-service teachers' full time teaching responsibility.

Data Analysis

Scaling Variables for MANOVA

Comparable to specifying contrasts among levels of independent variables, it is possible to specify contrasts among multivariate outcomes on multiple dependent variables. Standardized difference scores were computed to estimate the mean difference in terms of standardized units to facilitate comparisons between and within groups. This process provided insights about the relationships among the variables and to allow interpretation of pre to post-test effects across content knowledge for teaching mathematics (CKTM) and pedagogical content knowledge (PCK) domains. For example, the standardized difference formula for the CKTM geometry domain, $DK_G = \frac{K_{12} - \overline{K_{12}}}{S_{12}} + \frac{\overline{K_{12}} - \overline{K_{11}}}{S_{11}}$ was computed as a standardized difference z-score for the posttest (K12) and then the effect size in pre-test standard deviation units ($\frac{\overline{K_{12}} - \overline{K_{11}}}{S_{11}}$) was added to the standardized z-score ($\frac{K_{12} - \overline{K_{12}}}{S_{12}}$). The eight standardized difference scores (3 for CKTM, 5 for COPAT) for each of the twenty pre-service teachers (13-Elementary, 7-Middle) were analyzed using SAS. The variable labels used for each domain were: 1) the CKTM geometry (DK_G), number and concept (DK_{NC}), and algebra (DK_{AL}) content areas; 2) COPAT pedagogical domain 1 Instructional preparedness (DC_{IP}); domain 2 Instructional environment/management (DC_{EM}); domain 3 Instructional lesson (DC_{IL}); domain 4 Instructional monitoring (DC_{IM}); domain 5 Instructional motivation and feedback (DC_{IMF}).

The independent variable was certification level (1-elementary, 2-middle grade). Using the PROC GLM/MANOVA procedure in SAS, each of the eight domains were compared using multivariate “M function” contrasts. The purpose for using a multivariate contrast across multiple domains (3-CKTM; 5-COPAT) was to determine whether these domains differed on certification level in order to maintain as much power as possible by including all the data within contrasts. For each of the multivariate contrasts, the M Matrix calculated 22 newly transformed variables that tested the difference between sets of domains using balanced (or orthogonal) content knowledge and pedagogy domain combinations (See Tables 1, 2, 3, and 4).

Table 1

Multivariate Contrast Combinations

Transformed variable	Domain set 1	Domain set 2
m1	3 CKTM domains	5 COPAT domains
m2	Number/concept, algebra	5 COPAT domains
m3	Algebra	5 COPAT domains
m4	Geometry	5 COPAT domains
m5	Number/concept	5 COPAT domains
m6	Geometry, algebra	5 COPAT domains
m7	Geometry, number/concept	5 COPAT domains
m8	3 CKTM domains	DC_{IP}, DC_{EM}, DC_{IL}, DC_{IM}
m9	3 CKTM domains	DC_{IP}, DC_{EM}, DC_{IL}
m10	3 CKTM domains	DC_{IP}, DC_{EM}
m11	3 CKTM domains	DC_{IP}
m12	3 CKTM domains	DC_{IP}, DC_{IMF}
m13	3 CKTM domains	DC_{IP}, DC_{IM}, DC_{IMF}

Table 1 Continued

Transformed Variable	Domain Set 1	Domain Set 2
m14	3 CKTM domains	DC_{IP}, DC_{IL}, DC_{IM}, DC_{IMF}
m15	3 CKTM domains	DC_{EM}, DC_{IL}, DC_{IM}, DC_{IMF}
m16	3 CKTM domains	DC3, DC_{IM}, DC_{IMF}
m17	3 CKTM domains	DC_{IM}, DC_{IMF}
m18	3 CKTM domains	DC5
m19	3 CKTM domains	DC_{EM}
m20	3 CKTM domains	DC_{IL}, DC_{IMF}
m21	3 CKTM domains	DC_{IM}
m22	3 CKTM domains	DC_{EM}, DC_{IL}, DC_{IM}

Table 2

Multivariate Contrast Matrix 1

Transformed Variables	DK_G	DK_{NC}	DK_{AL}	DC_{IP}	DC_{EM}	DC_{IL}	DC_{IM}	DC_{IMF}	*p*-value
m1	5	5	5	-3	-3	-3	-3	-3	.0644
m2	0	5	5	-2	-2	-2	-2	-2	.0015**
m3	0	0	5	-1	-1	-1	-1	-1	.0014**
m4	5	0	0	-1	-1	-1	-1	-1	.0481*
m5	0	5	0	-1	-1	-1	-1	-1	.0041**
m6	5	0	5	-2	-2	-2	-2	-2	.3309
m7	5	5	0	-2	-2	-2	-2	-2	.3786

Wilks' lambda value: .184 ($p < .01$)
**Contrast is significant at the 0.01 significance level (2-tailed).
* Contrast is significant at the 0.05 significance level (2-tailed).

Table 3

Multivariate Contrast Matrix 2

Transform Variables	DK_G	DK_{NC}	DK_{AL}	DC_{IP}	DC_{EM}	DC_{IL}	DC_{IM}	DC_{IMF}	*p*-value
m8	4	4	4	-3	-3	-3	-3	0	.0825
m9	1	1	1	-1	-1	-1	0	0	.0796
m10	2	2	2	-3	-3	0	0	0	.0627
m11	1	1	1	-3	0	0	0	0	.0985
m12	2	2	2	-3	0	0	0	-3	.0407*
m13	1	1	1	-1	0	0	-1	-1	.0576
m14	4	4	4	-3	0	-3	-3	-3	.0745
m15	4	4	4	0	-3	-3	-3	-3	.0687

Wilks' lambda value .717 (p = .4003)
* Contrast is significant at the 0.05 significance level (2-tailed)

Table 4

Multivariate Contrast Matrix 3

Transformed Variables	DK_G	DK_{NC}	DK_{AL}	DC_{IP}	DC_{EM}	DC_{IL}	DC_{IM}	DC_{IMF}	*p*-value
m16	1	1	1	0	0	1	1	1	.0875
m17	2	2	2	0	0	0	-3	-3	.0691
m18	1	1	1	0	0	0	0	-3	.0409*
m19	1	1	1	0	-3	0	0	0	.0568
m20	1	1	1	0	0	-3	0	-3	.1898
m21	1	1	1	0	0	0	-3	0	.1536
m22	1	1	1	0	-1	-1	-1	0	.0915

Wilks' lambda value = .749 ($p = .3310$)
* Contrast is significant at the 0.05 significance level (2-tailed).

The new mean score for each transformed variable, (m1-m22), found average differences between the sets of content knowledge for teaching mathematics domains and sets of pedagogy domains. For example, the transformed variable, m1, contrasted the weighted average $5\times$ ($DK_G + DK_{NC} + DK_{AL}$) minus the weighted average of -3 $\times$ ($DC_{IP} + DC_{EM} + DC_{IL} + DC_{IM} + DC_{IMF}$). Statistically significant differences ($p < .01$) found on three transformed variables (m2, m3, and m5) were examined for directional mean differences within certification level (1-elementary, 2- middle). Error rate was reduced by setting Type I error rate per comparison at .01. While the experimentwise error rate still approached 1.0 for at least one difference due to chance, this was balanced by the need to maintain reasonable power for the contrasts.

Results

This study examined whether trends or factors emerged between pedagogical content knowledge (PCK) domains and content knowledge for teaching mathematics (CKTM) domains. Results from analyzing difference scores using multivariate contrasts will discuss relationships among the domains and determine whether these domains differed on certification level. Results from MANOVA will show how elementary and middle grade level pre-service teachers differed between PCK and CKTM domains.

CKTM and COPAT Multivariate Contrast Differences

After completing multivariate contrasts among groups of the CKTM and COPAT domains on certification level, statistically significant differences ($p < .01$) were found on certification level between three transformed variables: a) number/concept and algebra, b) number/concept, and c) algebra CKTM domains contrasted with the five COPAT pedagogical domains. (See Tables 2, 3, 4, and 5). The MANOVA criteria output defined by the M Matrix transformation, showed Wilks' Lambda was statically significant, $\Lambda = .184$ ($p < .01$)[1].

Directional differences on certification level between statistically significant ($p < .01$) transformed variables were then analyzed to determine within group differences. The transformed variable, m2, that contrasted the number/concept and algebra CKTM

---

[1] An example of the syntax for the "M function" orthogonal contrast matrix was computed as

```
proc glm;
class Certlevel;
model DK1 DK2 DK3 DC1 DC2 DC3 DC4 DC5 = Certlevel;
means Certlevel;
manova h = Certlevel
 m = (1 1 1 0 0 -1 -1 -1)
Mnames = m1 m2 m3 m4 m5 m6 m7 m8/summary; run;
```

domain with the five COPAT pedagogical domains showed that elementary pre-service teacher scored a higher combined number/concept and algebra CKTM mean difference ($\overline{X}$ = 17.21, *SD* = 12.39) than the middle grades pre-service teachers ($\overline{X}$ = -1.21, *SD* = 5.04) with a mean difference between the groups of 18.41. The transformed variable, m3, that contrasted the algebra CKTM domain with the five COPAT pedagogical domains showed the elementary pre-service teachers also had a higher algebra mean difference ($\overline{X}$ = 5.48, *SD* = 5.74) than the middle grades pre-service teachers ($\overline{X}$ = -3.74, *SD* = 3.92) with a mean difference between the groups of 9.22. The transformed variable, m5, that contrasted the number/ concept CKTM domain with the five COPAT pedagogical domains showed that the elementary pre-service teachers had a higher number/concept mean difference ($\overline{X}$ = 11.73, *SD* = 7.05) than the middle grades pre-service teachers ($\overline{X}$ = 2.53, *SD* = 2.79) with a mean difference between the groups of 9.20 (See Table 5). Examination of how elementary and middle level pre-service teachers performed on each specific CKTM and PCK domain were further explored.

Table 5

Directional Multivariate Contrast Differences

Contrast	Certification Level	*N*	Mean Difference	*SD*	*p*-value
c1	Elementary	13	12.88	17.47	.0644
	Middle	7	-.6784	5.99	
c2	Elementary	13	17.21	12.39	.0015**
	Middle	7	-1.21	5.04	
c3	Elementary	13	5.48	5.74	.0014**
	Middle	7	-3.74	3.92	
c4	Elementary	13	-4.33	5.90	.0481*
	Middle	7	.5311	1.46	
c5	Elementary	13	11.73	7.05	.0041**
	Middle	7	2.53	2.79	
c6	Elementary	13	1.15	10.92	.3309
	Middle	7	-3.21	4.57	
c7	Elementary	13	7.39	12.25	.3786
	Middle	7	3.06	3.87	

**Contrast is significant at the 0.01 significance level (2-tailed).
* Contrast is significant at the 0.05 significance level (2-tailed).

Separate CKTM and COPAT Domain Differences and Rankings

After investigating results on sets of content knowledge for teaching mathematics (CKTM) domains and sets of pedagogy domains using the COPAT, standardized difference scores from each of the eight domains (3-CKTM, 5-COPAT) were analyzed separately on certification level. MANOVA results showed statistically significant differences ($p < .01$) on all three CKTM domains but no statistically significant differences were found on any of the five COPAT domains (See Tables 6 and 7).

Table 6

CKTM Domain Differences

Domain	Level	*N*	Mean	*SD*	*p*-value	Partial Eta Square
DK_G	ELS	13	-.99	.88	.002*	.43
	MLS	7	.35	.52		
DK_{NC}	ELS	13	2.22	.75	<.001*	.52
	MLS	7	.75	.63		
DK_{AL}	ELS	13	.98	.71	<.001*	.52
	MLS	7	-.50	.70		

*Factor is significant at the 0.01 significance level (2-tailed).

Table 7

COPAT Domain Differences

Domain	Level	*N*	Mean	*SD*	*p*-value	Partial Eta Square
DC_{IP}	ELS	13	-.17	1.15	.45	.03
	MLS	7	.19	.79		
DC_{EM}	ELS	13	-.08	1.14	.30	.06
	MLS	7	.41	.63		
DC_{IL}	ELS	13	-.07	1.18	.67	.01
	MLS	7	.14	.60		
DC_{IM}	ELS	13	-.04	1.10	.68	.07
	MLS	7	.52	.73		
DC_{IMF}	ELS	13	-.23	1.14	.25	.01
	MLS	7	-.03	.72		

*Factor is significant at the 0.01 significance level (2-tailed).

Both elementary and middle level student teachers had the highest mean difference in the CKTM number/concept domain (elementary $\overline{X}$ = 2.22, *SD* = .75; middle $\overline{X}$ = .75, *SD* = .63). Elementary level pre-service teachers had their second highest difference score in algebra ($\overline{X}$ = .98, *SD* = .71), followed by geometry ($\overline{X}$ = -.99, *SD* = .87). Conversely, middle grade level pre-service teachers had their second highest difference score in geometry ($\overline{X}$ = .35, *SD* = .52), followed by algebra ($\overline{X}$ = -.50, *SD* = .70) (See Table 7).

Even though there were no statistically significant differences between the five pedagogical teaching behaviors, there were differences between domain rankings. For example, elementary pre-service teachers had the highest mean difference for instructional motivation and feedback, $\overline{X}$ = -.23, whereas it ranked lowest for the middle level, $\overline{X}$ =-.03. In addition, with the exception of instructional motivation and feedback (DC_{IMF}), the middle grade level pre-service teachers had all positive mean differences, in comparison to the elementary level pre-service teachers, which had all negative mean differences (See Table 8).

Table 8

Mean Rankings (Highest-1 to Lowest-5) on Certification Level

Rank	CKTM			COPAT			
	Domain	ELS Δ	MLS Δ	Domain	ELS Δ	Domain	MLS Δ
1	DK_{NC}	2.22	.75	DC_{IMF}	-.23	DC_{IM}	.52
2	DK_{AL}	.98	.35	DC_{IP}	-.17	DC_{EM}	.41
3	DK_{G}	-.99	-.50	DC_{EM}	-.08	DC_{IP}	.19
4				DC_{IL}	-.07	DC_{IL}	.14
5				DC_{IM}	-.04	DC_{IMF}	-.03

Discussion

This study found that by examining differences between pedagogical content knowledge domains with content knowledge for teaching mathematics domains that elementary level pre-service teachers had a better understanding of number and concept and algebra content knowledge for teaching mathematics domains and middle grade level pre-service teachers demonstrated higher performance using pedagogical content knowledge skills. Similar studies have examined the development of either pedagogical or content knowledge for teaching mathematics of pre-service teachers and found that a solid foundation and understanding of content knowledge is a strong predictor of successful classroom instruction (Ball & Wilson, 1990; Blanton, Berenson, & Norwood, 2001; Capraro et al., 2005). This finding aligns with the fact that most teacher preparation coursework is content-based with only a few courses on pedagogy, such as classroom management or math methods (Chen & Ennis, 1995).

Why did elementary level pre-service teachers demonstrate higher levels of content knowledge for teaching mathematics than middle grade pre-service teachers? Perhaps the level of engagement demonstrated by the elementary level pre-service teachers was higher than the middle grade pre-service teachers when they answered the questions on the CKTM posttest. Both groups had completed their student teaching experience and were preparing to graduate and find teaching positions. An item analysis of both groups found that the elementary grade level pre-service teachers only had gains from pre to post test on both the number/concept and algebra tests, whereas, the middle grade level pre-service teachers had mostly losses from pre to post, with one pre-service teacher having a loss of 13 points on the algebra test. Also, the nature and development of the CKTM test items for each group may have affected their pre to post score differences.

Conversely, why did middle level pre-service teachers demonstrate higher levels of pedagogy content knowledge than content knowledge for teaching mathematics? Middle grade level pre-service teachers may have had higher PCK scores than elementary level pre-service teachers because they selected the mathematics class in which the researcher observed them. Elementary level pre-service teachers usually had the same group of students all day, whereas middle grade pre-service teachers had several different groups of students. Because of natural variation in classroom composition, student behavior, and inclusion, some classes may have been more naturally conducive to allowing a greater (or more complete) display of PCK factors. Typically, the middle grade pre-service teacher would invite the researcher to observe them in well-behaved and/or academically advanced class. This tended to make it more likely for them to maintain effective classroom management, organize and execute the lesson with minimal student interruptions, and therefore earn higher pedagogical scores. Whereas, in elementary school, the classroom student composition did not change throughout the day; the pre-service teacher taught the same group of students for the entire day.

The number/concept content domain scores were highest for both groups of pre-service teachers possibly because most of their observed mathematics lessons used skills and objectives from this domain. They had more time to practice teaching number and concept skills, such as addition and subtraction, to their students throughout their student teaching experience. Further investigation of in-class teaching experiences would be an additional method for understanding differences and relationships between the groups.

Preparing pre-service teachers to know both content knowledge and pedagogy is not an easy objective to achieve in teacher preparation programs. Typically, emphasis in teacher preparation programs has been placed on learning mathematical content knowledge, but not necessarily the content knowledge needed to teach mathematics. This knowledge, compounded with learning how to use pedagogical content knowledge skills in the classroom, makes understanding how to teach mathematics a common challenge faced by pre-service and novice teachers.

The ability to teach mathematical content to students is influenced by both CKTM and PCK. Ball's (2001) research focuses on in-service teachers' level of CKTM. This research extends her work to pre-service teachers by examining current practice in the preparation of teachers. This work incorporates an added dimension by triangulating the results of CKTM using a classroom observation instrument that allowed an understanding of pre-service teachers' actual teaching practices. Therefore, this report situates CKTM within actual classroom teaching practices as measured on eight domains. These findings emphasize how the practice of mathematical teaching is a combination of both specialized and common content knowledge that teachers need to amalgamate in order for effective instruction to occur. The interactions and experiences elementary and middle grade level pre-service teachers had with mentors, students, parents, administrators and other educators throughout their student teaching experience resulted in a nexus between both content knowledge for teaching mathematics (CKTM) and pedagogical content knowledge (PCK) domains. It is within this nexus where the amalgam forms inexorably unifying CKTM and PCK. For example, the elementary level pre-service teachers had less content knowledge coursework than middle grade pre-service teachers but improved their CKTM scores as a result of their student teaching, which involved in-depth mathematics teaching. Likewise, the middle grade pre-service teachers, who had sufficiently more mathematical content knowledge coursework than elementary level pre-service teachers, improved their PCK throughout student teaching from similar engaged activities. These differences for both groups of pre-service teachers resulted from their teaching experiences and helped to form the amalgam between CKTM and PCK.

However, further questions still arise. Such as, what role did the cooperating teacher, the types of mentors and students in the classroom have on the pre-service teachers' CKTM and PCK development? Is the 12 weeks of student teaching enough time to sufficiently prepare pre-service teachers to enter the workplace or would year-long internships be better suited? The interplay between CKTM and PCK is not easy to disentwine and comprehend. Further research is needed to better understand the complexities and nuances involved in the preparation of mathematics teaching and student teaching experiences.

CHAPTER III

MENTORING URBAN INTERNS: AMALGAMATION OF EXPERIENCES IN THE FORMATION OF MATHEMATICS TEACHERS

Introduction

Educating and retaining first year interns who teach mathematics in urban schools is an important area of research that needs to be better understood (Austin & Fraser-Abder, 1995; Bartell, 2005; Walker, 2007; Wolf, 2003). Even though the difficulties of teaching in urban schools are well documented (Claycomb, 2000; Thompson & Smith, 2005; Wilson, Floden, & Ferrini-Mundy, 2001) as are the difficulties of teaching mathematics (Ball, Lubienski, & Mewborn 2001; Cwikla, 2007; Ma, 1999) and challenges facing urban internship programs (Bleach, 1999; Darling-Hammond, 2000; Feiman-Nemser, Parker, & Zeichner, 1993; Ng, 2003), few studies have focused on the combined effects of interns teaching mathematics in urban settings. By examining the challenges faced in each of these three areas, research has shown that: (a) due to teacher shortages in content areas, such as mathematics, many students in urban schools only a have 50 percent chance of being taught by qualified teachers (Bartell, 2005; Claycomb, 2000; The Urban Teacher Challenge, 2000); (b) new teachers, such as interns, specializing in mathematics or science were 10% more likely to leave teaching at the end of their first year of teaching than teachers specializing in other content areas (Smith & Ingersoll, 2004); and (c) the mentor's role as facilitator and guide for interns cannot be indiscriminate or planned haphazardly, but with specific, clear, and obtainable goals (Hudson & Peard, 2005). The amalgamation of this research invokes the question, how does providing a combination of mentoring field experiences for first year interns teaching mathematics in urban schools affect their development of mathematics teaching and pedagogical skills? This article focused on answering this question through the perspectives and experiences described by elementary and middle level first year interns teaching mathematics in urban school settings. Since much of the success of interns is measured by the quality of mentoring support they receive, we need to also understand the unique roles and conditions faced by mentors in urban schools (NCTM, 2007).

Mentor Roles and Responsibilities

The roles and responsibilities of mentors are also an important component of a successful internship experience. The diverse nature of mentoring requires that mentors function in several capacities. Dynak and DeBolt (2002) described mentor roles and requirements, such as:

> (a) supporting, facilitating, and challenging novices into standards-based practice; (b) facilitator of self-reflection, problem-solving, and instructional improvement; (c) interactions between mentor and novice are both formal and informal, occurring in and out of the mentor's and/or novice's classroom; and (d) provides empathy and assistance to novices coping with the stresses of teaching (p. 78-79).

Zachary (2000) stated that mentors should have the following skills when working with interns: building and maintaining relationships, coaching, communicating, encouraging, facilitating, guiding, managing conflict, problem solving, providing and receiving feedback and reflecting. The roles and responsibilities of mentors within teacher preparation programs should be clearly defined and understood in order to facilitate and guide interns.

Mentoring Urban Interns in Mathematics

High quality urban mentors facilitate and support interns in the learning and teaching of mathematics strategies and concepts. Gimbert, Bol, and Wallace (2007) found that since urban schools have low retention rates for teachers, especially in the area of mathematics, being a mentor in an urban school requires additional skills that are conducive to the demanding routines and frustrations of the urban school environment. Successful urban mentors help interns develop resilience to the demanding routines and frustrations of teaching; enjoy working with urban students; and are willing to assist interns to understand, grow, and thrive within the urban context (Bartell, 2005; King & Bey, 1995). Additionally, Guyton and Hidalgo (1995) described the role of an urban mentor as having a clear sense of self, being a successful teacher, an expert with multicultural perspectives and having strong interpersonal skills.

Another conundrum facing urban interns is the effective teaching of mathematics. Austin and Fraser-Adber (1995) concluded that “mentors need to become an integral part of teacher education as interns prepare for the realities of teaching mathematics and science in urban communities” (p. 85). One reality that mentors face is the recognition that interns are not equipped, in many ways, to teach mathematics. Common to first year teachers, interns bring their own mathematical misconceptions and beliefs into the classroom and quickly find that they need to deepen and extend their subject matter knowledge and understanding of how to teach that knowledge to students

(Wolf, 2003). This understanding involves having both 'common' and 'specialized' mathematical content knowledge. Many interns have a solid understanding of 'common' mathematics knowledge, but lack the understanding and ability to teach using 'specialized' mathematics content knowledge (Ball, Bass, & Hill, 2004). 'Common' knowledge is the essential algorithmic and procedural knowledge necessary for computing mathematical solutions. 'Specialized' knowledge is the skills, procedures, and competencies needed for teaching mathematics to students. Examples of 'specialized knowledge' include (a) knowing how mathematical ideas are related and how they can be represented in multiple ways; (b) responding to students mathematical questions and ideas in ways that promote their learning; and (c) being able to implement norms of discourse and framing of mathematical questions (Heaton & Lampert, 1993: McDiarmid, Ball, & Anderson, 1989; Wolf, 2003). Mathematics teachers need both types of knowledge to teach effectively so they can "unpack" mathematical ideas and procedures for their students (Ball, 2001). Using this type of mathematics knowledge aligns with the NCTM (2000) Teaching Principle that states, "effective mathematics teaching requires understanding what students know and need to learn and then challenges and supports them to learn it well" (p. 16).

Interns rely on their mentors to provide them with modeling, support, and guidance of how to implement and teach mathematics concepts and skills. Unfortunately, many mentors do not have the skills, training, or education to effectively mentor beginning mathematics teachers (Hudson & Peard, 2005). Increased studies are needed to understand the factors and implications of educating, mentoring, and retaining mathematics interns in urban schools.

This study examined the mathematics mentoring support perceptions of first year teachers who participated in a year-long urban internship program. These perceptions, gathered through interview data, were investigated to explore individual differences between elementary and middle level interns as experienced within the context of mathematics teaching and what specific pedagogical factors may have influenced their ability to teach mathematics. Prior research has shown that urban interns face many challenges in learning to teach and rely on effective mentoring programs (Schoon & Sandoval, 2000). Research has shown that teaching mathematics is a struggle for many first year interns (Featherstone, 2007) and compounded for interns in urban schools (Wang & Odell, 2003).

Methodology

Research Questions

This study was designed to show the double jeopardy pre-service teachers, such as interns, may encounter teaching mathematics in urban schools and how mentors can play a critical role in their success and retention. The specific research questions examined in this study were measured through semi-structured interviews describing the interns' mathematics teaching and mentoring experiences throughout their initial year of teaching. The research questions were (a) how did various roles of mentors help develop urban interns' ability to teach mathematics? (b) What specific teaching skills, factors, and pedagogical behaviors helped or hindered urban interns' ability to teach mathematics?

Participants

Eight elementary and three middle level pre-service teachers comprised a purposively selected sample of interns completing their first year-long teaching experience in low socioeconomic, highly diverse, urban school districts situated in south-central Texas. All of the elementary and middle level interns were White and female with the exception of one, Hispanic male (See Table 9). Seven elementary level interns taught kindergarten through 4^{th} grade, and one taught a self-contained *English as a Second Language* (ESL) class. Three middle level interns taught 5^{th}, 7^{th} and 8^{th} grade regular mathematics classes containing inclusion students. No classes were identified as advanced.

Table 9

Description of Interns

Intern	Gender	Certification Level	Grade	Subjects taught
Fran	F	Early Childhood (K-4)	kindergarten	Math, Language Arts, Science, Social Studies
Heather	F	Early Childhood (K-4)	kindergarten	Math, Language Arts, Science, Social Studies
Betty	F	Early Childhood (K-4)	1st	Math, Language Arts, Science, Social Studies
Connie	F	Early Childhood (K-4)	1st	Math, Language Arts, Science, Social Studies
Wendy	F	Early Childhood (K-4)	2nd	Math, Language Arts, Science, Social Studies
Karen	F	Early Childhood (K-4)	3rd	Math, Language Arts, Science, Social Studies
Denise	F	Early Childhood (K-4)	4th	Math, Language Arts, Science, Social Studies
Teresa	F	Math/Science (5-8)	5th	Math, Language Arts, Science, Social Studies
Andrea	F	Math/Science (5-8)	7th	7^{th} grade level Math
Paul	M	Math/Science (5-8)	7-8th	7^{th}-8^{th} grade level Math

Setting

The internship program was designed to place interns with high-needs students in urban schools. The interns met the following requirements in order to participate in the internship program (a) completed their educational coursework and field-based clinical experiences; (b) obtained at least a 3.0 grade point average; (c) completed all degree requirements, except for student teaching; (d) successfully completed all written state teacher certification exams; (e) applied for a probationary teaching certificate; and (f) enrolled in six hours of graduate-level, internship-focused coursework. Interns were the teacher of record and were responsible for the same duties, responsibilities, and ethical considerations as other teachers in the district. They received a first year teacher's salary minus $8,000 for mentor support. This deduction was used to pay for a replacement teacher for the assigned district mentor (Helfeldt, Capraro, Capraro, Foster, & Carter, in press).

These urban internship schools had a student ethnic make-up of: White (11-73%), Hispanic (12-45%), African American (8-37%), and Asian (2-29%). Students receiving free and reduced lunches ranged from 17 to 74 percent. Four of the eight schools were Title I schools and eligible for participation in programs authorized by Title I of Public Law 107-110, the Elementary and Secondary Education Act of 2002.

Instrumentation

Audio-taped and transcribed semi-structured interviews were conducted by telephone in the last month of the internship program (i.e. 9th month of the school year). The interviews lasted on average 30 minutes. Eleven questions were designed for the interview with seven focused on specific mentor support; two focused on mathematics teaching; one focused on job employment for the next year and one focused on overall internship experience (See Appendix B). The purpose of the questions was to provide conversation starters and not intended to be all encompassing. This form of interviewing known as semi-structured interviewing (Seidman, 2006) provided insights while providing flexibility to probe in detail, ideas raised by the participants. Even though each question was asked to each intern, the researcher allowed the interns to expand upon answers, as desired.

A constant comparative data analysis based in grounded theory (Denzin & Lincoln, 2003) compared each of the interview answers between both groups (elementary level and middle level interns) for similarities and differences in mentoring support systems and pedagogical factors (Merriam, 1998). Data were chunked into small, meaningful units, coded, grouped together for similarities in frequency and description type, given category names, such as "planning of classroom activities and instruction" and then examined for themes or patterns in participants' responses to the interview questions. The researcher then re-read and re-coded the data to ensure trustworthiness (Denzin & Lincoln, 2003).

Research Design

Using grounded theory approach (Denzin & Lincoln, 2003) pattern similarities and differences in responses were examined. Each interview question was grouped by certification level (elementary and middle level) and question type, such as general pedagogy or specialized mathematics content knowledge. The transcribed dialogue for each participant was re-organized so that all participant answers were grouped with each question. Correlated word segments and phrases, such as ways interns used manipulatives, were further grouped together. Finally, key-words-in-context and word counts were used to reduce and further chunk together ideas, resulting in emerging themes and patterns of responses. An emergent design was also employed to examine common themes or ideas as they developed throughout the organization and examination of data results and transcribed text (Lincoln & Guba, 1985).

To ensure confidentiality, pseudonyms were used to protect the identity of the voluntary participants. Trustworthiness was established by: (a) collecting thick descriptive interviews, (b) engaging both the intern and researcher as conversational partners, (c) conducting a pilot study that examined pedagogical factors of former interns through in-class observations, and (d) consulting with mentoring and mathematics education experts (Denzin & Lincoln, 2003).

Results

The focus of this research examined urban interns' perceptions of their mentors' roles. Specific focus was on the teaching of mathematics and what specific skills, factors, and pedagogical behaviors helped or hindered their ability to teach mathematics. In this section, a description of mentors' roles, according to certification level, and pedagogical skills, factors, and behaviors that affected their ability to teach mathematics, will be explored and discussed.

Roles of Mentors

How Did the Campus Mentor Help Interns Develop Their Ability to Teach Mathematics?

Elementary level interns. The elementary level interns' campus mentors played a variety of mentoring roles and offered varying degrees of support and guidance. The interns' described behaviors that their campus mentor helped develop including both general pedagogical strategies and teaching mathematics skills (See Table 10). The campus mentor was typically a team leader, another teacher on the grade level team, another classroom teacher, or math specialist. One intern had a literacy coach provide mentoring support in regards to her teaching of mathematics because the math specialist was “spread too thin.

Table 10

Campus Mentor Support

Type of assistance/support	Elementary-level interns	Middle level interns
Pedagogical	Developing lesson plans Sharing ideas, worksheets, and supplies Showing new and creative ways to teach Making interns aware of other support personnel	Helping prepare and execute lessons Observing other teachers in the school
Mathematics teaching	Modeling a mathematics lessons Brain-storming different mathematics teaching techniques Showing how to differentiate mathematics instruction Making manipulatives	Developing effective mathematics assessment strategies Leveling mathematics content for students in different class periods Providing alternative teaching styles and explanations for one topic

The types of pedagogical assistance that elementary level interns received from their campus mentor included: (a) developing lesson plans, (b) sharing ideas, worksheets and supplies, (c) providing classroom management strategies, (d) showing new creative teaching strategies, and (e) making interns aware of other support personnel. Only one intern reported that her campus mentor was not much support:

> We had a new teacher mentor on our campus. But she really didn't do anything. She was actually kinda horrible. I had heard other teachers at their schools say their teacher mentor did all this great stuff, but mine didn't.

Fortunately, most elementary level interns had good experiences with their campus mentors. Descriptions of mentor experiences included: "It was a very good experience. I very much enjoyed it," and:

> . . . there are always things that you're not going to learn until you are out there doing it. A lot of the teachers in the building felt that we were more prepared now than they were when they came into the teaching. So, that is a confidence boost to hear someone say that . . . you seem prepared and know what you are talking about. So, I felt good about it, overall.

The interns completed lesson planning individually, in conjunction with team members, and district personnel. A few districts created and planned lessons for teachers to revise and modify fitting the needs of their students. Initially, several of the interns did this with the help of their campus mentor, but after the second semester of school, most began revising lesson plans on their own.

Mathematics teaching support and guidance was provided by the campus mentor in a variety of ways: (a) making manipulative, such as base 10 blocks, (b) actually teaching or modeling a mathematics lesson, (c) brain-storming different teaching techniques when a lesson was not successful or objectives were not achieved, and/or (d) showing interns how to differentiate mathematics strategies for high and low-performing students. One second grade intern reported:

> There were some things that I would try and it wouldn't go so well [when I taught it to my students]. So my mentor and I would brainstorm different ways that I could change it up, like with 2 digit subtraction with the regrouping. Some of my kids had a hard time with that and not being able to see it. So we tried ways [for students] to see it [subtraction] differently. Little rhyming jingles helped them remember. She [mentor] helped me to differentiate with my kids because they had a hard time understanding different concepts in math. That was a challenge for me because it was so different and there was not a lot of students 'in the middle." I had a lot of high kids and a lot of struggling math students in the same class.

Mentoring the teaching of mathematics focused on ways to teach mathematics that may not have been the traditional method interns learned when they were in school. Being able to effectively teach mathematics to differing levels of students within the same classroom was also a topic discussed with their campus mentor. At least two of the interns did not have mathematics resources for games and lessons.

There was quite a bit of variability in the amount of times per semester the campus mentor observed the interns in their classroom. Some campus mentors never saw their intern teach and others were in the classroom observing and helping them everyday. Since several of the campus mentors were also classroom teachers, they were unable to leave their room and spend time observing the interns teaching. One campus mentor who observed her intern more frequently had a connecting classroom with her. Most observations were informal, rather than formal. Paige stated that "I would go down to her [my campus mentor's] classroom and ask her questions and she might come to my classroom after school or during lunch and ask me how I was doing and give me advice." Elementary level interns who experienced successful and supportive mentoring support from their campus mentor usually received frequent and consistent feedback from in-class observations, modeling of lessons, and pedagogical assistance concerning classroom management strategies and skills.

Middle level interns. Two of the three middle grade interns characterized their campus mentors as providing effective mathematics teaching support. Paul stated that:

> I think I might have drowned if I didn't have her. I feel that my teaching abilities developed by . . . knowing what the flow of the subject material would be and what the kids struggled with and what they got, what I could spend more time on, what I could breeze through a little quicker . . . that is what my campus mentor really helped me to sort out.

In contrast, another 5th grade intern had a different experience with her campus mentor:

> She was a scatter brain. She had a lot of great ideas but I just don't feel that the reinforcement was there as much as it could have been. It was a lot of "well here is this idea and that idea", but there wasn't any support behind it.

The types of pedagogical strategies that middle level interns received from their campus mentor included: (a) helping to prepare and execute lessons, (b) being able to observe other classroom teachers, and/or (c) classroom management strategies. They also relied more upon their mathematics team, not just the team leader:

> We work very well as a team and without them I would have been dead in the water. It would have been horrible. They helped me prepare lessons. They did a great job of setting examples for the lessons on what they did for theirs. They would do one, and then I would do one. We would go back and forth and everyone just kinda shared who did what. I got to see an example of a good lesson and then also I got a chance to watch other teachers and see how they worked and got prepared. It showed me a lot about what I needed to do with my lesson and what areas I needed to focus on.

Mathematical teaching focused on (a) developing effective assessment strategies, (b) leveling mathematics content for students in different class periods, and (c) providing alternative teaching styles and explanations for one topic.

Andrea and Paul planned weekly mathematics lessons with their team. Andrea's team would alternate each week with planning as a team and with the mathematics department. Teresa planned all lessons by herself with minimal or no support from her campus or team members.

A comparison of the campus mentor for both groups found that elementary level interns relied more on one mentor, whereas middle level interns relied on their entire team and not just one mentor. Also, none of the campus mentors observed any of the middle school interns in their classroom, whereas elementary level interns were observed more frequently.

How Did the District Mentor Help Interns Develop Their Ability to Teach Mathematics?

All eleven interns provided the researcher with the most description and detail about support given by district mentors. Interns were most eager to discuss their pedagogical and mathematics teaching interactions and experiences with their district mentor. Teresa best summed up the feelings reflected by all of the interns:

> She was amazing. She was really good. She brought in materials, she supported me, and she was wonderful. She did everything . . . She showed me resources and books and explained things to me. She just helped all around, pretty much.

The district mentor was appointed by the university in which each intern was enrolled. The district mentors were either retired teachers, had at least five years of successful district teaching experience and received developmental mentoring training. Each mentor was typically responsible for supervising 5-6 interns each year and was considered the liaison between the university, school district, and intern.

Elementary level interns. Types of general pedagogical assistance that elementary level interns received from their district mentor included: (a) organizing lesson plans, (b) making copies, (c) suggestions for improving their teaching, (d) helping develop lesson closure, (e) providing informal and formal feedback from observations, and (f) developing classroom management strategies (See Table 11).

Table 11

District Mentor Support

Type of support/assistance	Elementary-level interns	Middle level interns
Pedagogical	Developing classroom management strategies	Developing classroom management strategies
	Making copies of worksheets	Providing support and encouragement
	Providing suggestions to improve teaching	
	Helping develop lesson closures	
	Providing informal and formal feedback on observations	
	Organizing and developing lesson plans	

Table 11 Continued

Type of support/assistance	Elementary-level interns	Middle level interns
Mathematics teaching	Working with students in small groups on math assignments	Providing computer support for a mathematics activity
	Providing mathematics literature books	Providing math resources, books, and activity sheets
	Providing mathematics curriculum materials and manipulatives	
	Providing ideas from the Texas Essential Knowledge and Skills (TEKS) district training	
	Helping them relate mathematics concepts to real-world experience	
	Helping them learn new strategies that are not traditional algorithms	
	Helping them use appropriate and grade level terminology	

At least two interns needed guidance incorporating effective lesson closures. Most district mentors observed the interns between 2-5 times each week but did not model lessons. However, a few mentors worked with students in small groups and provided interns with teaching suggestions while in the middle of teaching a lesson. Paige stated that:

> I think for the first 2-3 months, she [district mentor] would come in 2-3 times a week during my math lessons. She would watch them [the students] and help if I needed help. She would just kinda step in the middle of the lesson and whisper something in my ear that I needed to say. That helped a lot. She gave me

> feedback. She did some formal observations for me. She also helped with tutoring after school, with some math tutoring.

Mathematics teaching support and guidance was provided by the district mentor in a myriad of ways categorized into three areas: working with students, providing math resources and curriculum-based assistance. District mentors would often walk around classrooms and observe students completing assignments. A few would even work with small groups of students who needed more individualized assistance and instruction. Heather stated that, "the two main things that our district mentor helped with was making things and pulling small groups of kids." Wendy had similar interactions with her district mentor. "She would come in and observe what my kids were doing and how they were working out their problems." However, not all mentors actively participated in classroom lessons and interacted with students. Betty reflected on how her district intern would interact in her room:

> She [district mentor] was there all the time . . . she never taught a lesson or interfered. She just kinda sat and watched and once a week she would do a formal lesson observation where she would watch a lesson.

District mentors displayed various roles in how they interacted with students and interns during classroom instruction. Some were very involved and others were more silent observers. Both types of interactions were well appreciated and accepted by interns. Mathematics resources that district mentors supplied to the interns included (a) mathematics literature books, such as the Marilyn Burns series, (b) curriculum materials and manipulatives, and (c) district training and ideas for implementing the *Texas Essential Knowledge and Skills* (TEKS), the state curriculum.

Mathematics curriculum and content support was provided by the district mentor in various ways. Interns reported mentors would help them to understand what their students' "switch" was and why the interns were not making the mathematics curriculum "click" for their students.

> It helps a lot just to have that support with my students that I couldn't exactly understand what it was. . . what their switch was that wasn't making it click for them since I hadn't had the experience that she [district mentor] had. So she would tell me what she thought was going on and so we would try a different way and talk about it. She always listened and asked questions and got me to see what I could improve on without her saying this is what you need to change. She tried to get me to reflect upon it, to see where I could improve.

Mentors also gave advice on using specific mathematics techniques, such as relating mathematics concepts to real-world experiences, learning new strategies that were not traditional algorithms, and using appropriate and grade-level terminology with the students. Denise reported that:

> Some things that I found were difficult with math were teaching long multiplication and long division. She [district mentor] taught us a lot of strategies to teach the kids that weren't just the traditional algorithms. So she helped me to figure out how to take what I had learned and then put it in their vocabulary so they could learn it.

Only one intern reported that her district mentor did not provide much assistance in the teaching of mathematics. She stated that:

> She [the district mentor] would observe and give feedback. That was helpful. Her specialty area wasn't really kindergarten so, as far as specific instruction in math; we got that more from our campus people. But she helped to make materials, helped observe, and all that kind of stuff.

Middle level interns. The types of pedagogical assistance that middle level interns received from their district mentor included: providing classroom management strategies, support, and encouragement. The mentors observed interns at least once a week and helped them become more secure in their ability to teach mathematics and value internship experiences.

Limited mathematics curriculum and content support was provided by the district mentor, as described by the middle level interns. One intern received computer support for teaching mathematics and all three received support in providing mathematics resources, books, and activity sheets. Thus, most of their mentor support was focused on organization and gathering of teaching ideas but not on how to teach mathematics content. Middle level interns also described their mentors as being very supportive. Paul described his mentor "like a mom teaching me how to walk."

Overall, both groups received an abundance of encouragement and support from their district mentor. Elementary level interns received more mathematics content based assistance than did the middle level interns. The primary pedagogical assistance for both groups was in developing and reinforcing effective classroom management skills and strategies. Frequent in-class observations, reflections, and discussions about teaching behaviors were also evident by the district mentors in both groups.

How Did Administrators Help Interns Develop Their Ability to Teach Mathematics?

Only the mathematics or instructional specialist provided support directly related to mathematics and only three of the interns (both levels) stated that their principal provided any general support, at all. Betty stated that:

> Our principal at our school is kinda like a "needs to" know person. I guess you weren't really supposed to talk to her unless you really need to. Not in a bad way but I think she just figured that was why our district mentor was there, so we don't need to be bothering her.

Another intern stated that she “did not see her [the principal] much or talk with her much. “Our assistant principal resigned half way through the school year and we didn’t get another until the last six weeks of school. So she (the principal) was very overwhelmed.” Fran experienced a more supportive role with her principal. “If I ever had a problem, she [the principal] could really lead me into the right direction or lead me to the person that I needed to talk to.” Most principals completed one formal observation during the year.

The mathematics specialist provided both elementary and middle level interns with mathematics support to prepare them for the state mandated exams and showed them how to use mathematics manipulatives. Teresa attended a district mathematics workshop focusing on how to teach to different academic levels of students and how to close the learning gap between high and low mathematics level students. Most of the principals assumed authoritarian roles and did not interact frequently with the interns. Only one intern described having a supportive role with her principal.

Overall Rating of Mentoring Experience

Both elementary and middle level interns reported having successful and rewarding internship experiences as a result of combined mentor roles. These roles helped provide support, guidance, and leadership needed throughout their first year of teaching. The two mentor roles that most influenced and supported the interns were the campus and district mentors. Middle level interns relied more on their team of mathematics teachers than did elementary interns. Additionally, elementary interns received more mathematics content support from their district mentor, than did the middle level interns. Both groups reported receiving sufficient general pedagogical support, especially within the areas of lesson design and implementation of classroom management strategies. However, most interns reported that they would still like to improve in both these areas.

This study focused on the various roles mentors played in developing urban interns' teaching abilities. However, what additional specific teaching skills and factors helped or hindered their ability to teach mathematics? Many of the mathematics skills interns learned and developed were a direct result of their mentors' guidance and teaching assistance. The next section discusses what specific mathematics skills, factors, and behaviors interns believed either promoted or hindered their ability to teach mathematics.

Utilization of Mathematical Skills, Factors, and Behaviors

The mathematics skills, factors, and behaviors described by elementary or middle level interns focused on what they perceived helped or hindered their ability to teach mathematics. All mathematics skills, factors, and behaviors described by the intern were situated within the context of teaching mathematics in their classroom throughout their year-long teaching experience.

Skills, Factors, or Behaviors Instrumental in Teaching Mathematics

Three general categories emerged after organizing, chunking, and coding the data for skills, factors, or behaviors interns' reported as being instrumental in their ability to teach mathematics: (a) use of manipulatives, (b) planning of classroom instruction and activities, and (c) execution of lessons (See Table 12).

Table 12

Factors, Skills, or Behaviors That ***Enabled*** *Elementary and Middle Level Interns to Teach Mathematics*

Use of manipulatives	Allowing students to "play" with manipulatives before using them for instruction
	Connecting manipulatives to real-life experiences
	Using manipulatives with bilingual students to help them understand mathematical concepts due to gaps in their English vocabulary
Planning classroom instruction and activities	Using both student-centered and teacher-centered instruction
	Using Bloom's Taxonomy to write lesson objectives
	Knowing how to structure a lesson to fit within the allotted class time
Execution of the lesson	Taught lessons using math tubs, multi-level learning groups, and whole groups activities
	Most activities involved movement and using hands-on manipulatives materials
	Using a variety of instructional techniques, such as visual cues, "think, pair, share" and alternative algorithms
	Using guided practice throughout instruction
	Showing students more than one way to solve a math problem

Descriptions and dialogues were used to delineate each group of interns and common themes and patterns within and between the groups were discussed.

Use of manipulatives. Being able to teach, explain, and model abstract representations to students is fundamentally important for mathematical development to occur at any grade level. One of the primary goals as teachers is to allow students the ability to develop conceptual knowledge as stated in the National Council of Teachers of Mathematics (NCTM, 2000) standards. Using concrete representations, such as manipulatives, can be a tool in helping students understand concepts. Examples of manipulatives used by interns include Cuisenaire rods, base 10 blocks, unifix cubes, fractions strips, dice, and rulers.

Elementary level interns frequently employed manipulatives to engage students and promote understanding. Several elementary interns allowed their students to “play” first with manipulatives before incorporating them formally into the lesson. Fran stated:

> For me and math, it was showing them and giving them examples and letting them touch it [the manipulatives] and do it themselves. My students were much more successful when I let them touch the manipulatives and experiment with them and then actually do something with them. Because if you're just standing up their teaching it by yourself, there is only so much that they are going to get. They're going to get a lot more if they are actually doing it.

Interns also tried to connect manipulatives to ideas or experiences that students had in real-life. Denise stated that:

> I loved using manipulatives. I taught in a Title 1 school, so it was primarily low income and I think that because of the lack of experiences that kids had, that it is so important to bring those [manipulatives] into the classroom. I tried to have something for them to touch and physically see whatever I was trying to teach them. Every unit had something different.

The bilingual intern, Paige, felt that manipulatives helped her students learn mathematics. “We used a lot of manipulatives. That helped a lot with the bilingual kids. They had a lot of gaps in their vocabulary.” To some degree, all elementary level interns used manipulatives. Some were pre-made, such as hand clocks, or fraction pieces, and others were hand-made or store bought, such as goldfish or flashcards. Two middle level interns stated that they used manipulatives to foster instruction. Andrea stated that it was difficult to use manipulatives because of the shortened 45 minute class periods.

> With the 45 minutes for each class it was really hard to incorporate [the manipulatives]. It was something that we talked about at our meetings a lot. But we had snap cubes; I think they're called, to help make 3-D objects. We had some laptop carts available for just the math department that had some math programs on them to help with basic computational skills.

Teresa also used manipulatives in her classroom:

> [We used] a ton of manipulatives. I actually have these math tool kits that I put together and plastic clear shoeboxes and they have base 10 blocks, unifix cubes, and Cuisenaire rods. They just have their own little math tool kits that they would go get and use whenever they needed them. So, yes there was definitely a lot of manipulatives being used.

Teresa stated that she learned how to use manipulatives from her math methods course, while Andrea reported attending district workshops that trained her on how to use manipulatives. Manipulatives were used by both elementary and middle level interns and they felt that it helped with instruction; however, using manipulatives effectively and correctly when teaching mathematics was a concern that a few interns expressed during the interview.

Planning classroom instruction and activities. Design and planning of mathematics instruction and activities within lessons is an essential part of teaching mathematics effectively. The design process includes deciding whether the delivery of instruction is to be teacher or student-centered. Characteristics of teacher-centered instruction include: (a) focus on the instructor, (b) teachers talk, students listen, (c) instructor monitors and corrects student utterances, (d) instructor chooses topics, and (d) quiet classrooms. Characteristics of learner or student-centered instruction include: (a) focus on both students and teacher, (b) focus on how students use mathematical language, (c) instructor modeling and students interacting with instructor and one another, (d) students working in pairs, in groups, or alone depending on purpose of activity; and (e) noisy and busy classrooms (National Capital Language Resource Center, 2006).

Both elementary and middle level interns used a combination of teacher and student-centered mathematics lessons. Several described their lessons as teacher-centered in the introduction of new material and student-centered in class activities. Paige explained her lesson structure:

> Researcher: Would you characterize your teaching as more teacher-centered, student centered, or both?
>
> P: Probably a combination, but definitely more student centered.
>
> R: So what kinds of things did you do to make it more student centered?
>
> P: I would model up there (in front of the class) and then I would give them a chance to do it, like an addition or subtraction problem. I would then go around and check their work.
>
> R: Did they work individually, in groups, or both?
>
> P: They did [it] all. They worked some individually. A lot of times I would do centers at the end of a lesson or a test, like geometry. They did centers and I had them split up into groups based on level.

Two kindergarten interns stated the majority of their mathematics lessons were always student-centered. Heather explained how the structure of a lesson can be difficult to plan and teach:

> It [planning lessons] helped me to figure out the structure of a math lesson. Like, what worked best for us is explanation and demonstration for the whole group, then practice with manipulatives where the kids get to work with them. . . So, I guess the thing that helped me teach math the most was figuring out the structure of a lesson because sometimes the lesson plans they had for us were really, really detailed, like overly detailed and so it was easiest for me to say, "whole group, practice, worksheet."

Andrea explained that even though she wanted to plan lessons that were mostly student-centered, they sometimes became more teacher-centered when actually taught.

> I wanted it to be more student centered, but I think in order to keep from drowning some times, it [teaching to students] would be whatever I could do [such as direct instruction]. I think a lot of that has to do with being a first year teacher. I tried to keep it as student centered, as I could.

Other important components of lesson planning include aligning objectives with activities and delivery of instruction. At least one intern used Bloom's Taxonomy when developing her lesson plans to ensure the activities were conceptually-based providing students opportunities to explore mathematical concepts. Wendy explained that she "would definitely use Bloom's Taxonomy. I would always try to apply that in math because it was very simple for me to think, oh, they understand how to do it and leave it at that." Actually stating the level of understanding that she expected from her students helped to ensure students understood the concepts.

Time management is a difficult organizational skill for beginning teachers. Knowing how to structure a lesson so that maximum learning can occur within the allotted time frame is challenging. Teachers run out of time and they forget lesson closure. Ensuring adequate time management, developing lessons that specify the level or degree of understanding; and deciding the appropriateness of teacher or student-centered lessons were a few areas of lesson planning and structure that interns expressed as instrumental in teaching mathematics.

Execution of the lesson. Even with careful preparation, lessons do not always unfold as planned, students do not always behave, nor do they always understand what is taught. So, what is a novice intern to do? This section explores what skills, factors, and behaviors interns felt were instrumental in the execution and teaching of mathematics lessons.

Elementary level interns used a student-centered approach with math tub centers, multi-level learning groups, and whole group activities. Betty used math tubs containing different mathematics activities. Students rotated every 30 minutes until each group had completed each tub. A new topic was taught by Betty on Monday and then students spent the remainder of the week completing each math tub and discussing what was learned in groups.

Denise used multi-level learning groups due to the social nature of her class. After she taught the main part of the lesson as a whole group activity, students would then be divided into high, medium, and low academic groups. "I would have my high kids doing TAKS [Texas Essential of Knowledge and Skills] activities and then do a small group of re-teaching with my low kids to bring them up to where my other kids were."

Most of the types of activities elementary-level interns used for behavior management involved movement and using hands-on manipulative materials. Descriptions of these types of activities included sorting and counting colors and shapes; finding the time on a clock; and using music to keep students on task. Denise stated:

> I tried to have something for them to touch and physically see whenever I was trying to teach them . . . like, when I taught measurement, it was important for me to bring in things for them to measure with. . . . like an inch is about the width of your forefinger. Different things like that so they could relate it to things that they actually know. That was really important.

Middle level interns used a variety of instructional strategies, including visual cues, guided practice, and think-pair-share and alternative algorithmic techniques. The visual cues used by Andrea included the overhead projector and hand gestures, stating that:

> I used lots of visual cues usually if it was a specific problem that they were having. . . for example if I am talking one-on-one with a child we can work through another problem or I would use lots of hand gestures, little poems so that they have some auditory mnemonic device to remind them how to do it. For multiplying fractions they had a little dance that they did . . . if they had top times top and bottom times bottom, they put their hands on their head and then their hands on her hips. So we were just trying to get a lot of different senses involved in it and let him come at it from different angles.

Paul used the think-pair-share instructional strategy to make his lessons more student-centered.

> I wanted them to work it out, wanted them to talk, pair up and talk about [the skills] and then we would talk about it as a class. It really helped the kids later on when we started working on that being more of a frequent thing in the class. It was something that I started doing in the second semester a lot more and watched a lot of [positive] differences in the students.

Paul also began to pace his teaching and provide more guided practice to students. “I spent the whole first semester in a real rush and expecting them to do what I wanted them to do without having shown them. So, I used a lot more guided practice and demonstrating and modeling of what I expected them to do and what I wanted them to focus on."

Teresa emphasized that there was more than one way to solve [math] problems and that learning math could be fun and interesting. She used math tool kits in her classroom to facilitate these ideas and strategies to her students.

Even though interns felt the skills, factors, or behaviors described above were instrumental in their ability to teach mathematics, they had some degree of difficulty implementing them effectively. However, most felt that using student-centered instruction was the most effective way to teach mathematics. The next section discusses which skills, factors, or behaviors interns felt hindered their ability to teach mathematics.

Skills, Factors, or Behaviors Hindering the Teaching of Mathematics

After coding, regrouping and categorizing the responses four hindering themes emerged: (a) mathematics-specific, (b) instructional-based, but not necessarily mathematics-specific; (c) mentoring-support based; and (d) general or non-content specific (See Table 13).

Table 13

*Factors, Skills, or Behaviors That **Hindered** Elementary and Middle Level Interns to Teach Mathematics*

Math-specific	Interns had to re-learn new mathematics concepts Had difficulty gaining access to district textbooks No monetary sources for purchasing manipulatives
Instructional-based, but not necessarily math-specific	Not having the opportunity to observe several teachers during their school practicum methods semester Lack of experience, lack of time for preparation and having to teach something new everyday
Mentoring-support based	Spending more time with grade level team members to go over lesson plans Lack of team planning support
General or non-content specific	Dealing effectively with disruptive students by using effective classroom management skills Concerned that students and parents would know her age

Mathematics-specific factors that elementary interns described included having to re-learn different ways of understanding mathematics concepts. Denise stated:

> When we were doing long multiplication and long division, I learned the traditional algorithm, but now they do completely different things that make it so much easier for them [students] . . . but I have no idea how to teach these things because I just know my way . . . but then once I went back and re-taught [myself] how to do these things, then I was able to teach it to my kids in a different way so they could understand it better.

Heather had difficulty gaining access to textbooks that her district used in planning lessons, as described:

> The thing that was hardest about math was that because our district pulls from different books, and the books were not always available. So, if you wanted to know more in-depth about a lesson, you couldn't find it . . . say they have a lesson in the plans that they have written for us. You don't really understand what it is telling you to do with the kids. It came from a book, but our district uses 15 different math books to put together the curriculum that we have. So, those books weren't always available for us to go get. So, if we wanted to know more about the lesson they wrote for us, we couldn't . . . we just had to figure it out ourselves.

Many of the interns did not have monetary resources to purchasing pre-made manipulatives, such as Cuisenaire rods, base 10 blocks, or geoboards. Two interns reported using their own money to purchase hands-on manipulatives. Despite having to purchase or create manipulatives, interns still felt the importance of using manipulatives regularly in the classroom to facilitate learning.

Paige described her lack of experience and daily lesson preparation as difficult for her and often times overwhelming. Wendy and Fran expressed difficulty in planning and working with students on varied academic levels. Differentiating the curriculum so that it was not too hard or too easy for the students and meeting the needs for each group were both challenges.

Two middle level interns described weaknesses in their mentoring support. Paul would have appreciated being able to spend a little bit more time going over lesson plans with his team members. He stated that he wished that, "we could have spent a little more detailed time . . . we were working as a team. We would just discuss the topic and everyone else had taught before and for me, being someone that hadn't seen the material or content before, it was rough for them to just say, ok, here you go." Teresa had previously expressed lack of support from most of her campus mentors, so the lack of planning lessons and team planning support made it more difficult for her to have a successful mentoring experience. Fortunately, her district mentor provided most of the support she needed.

General or non-content specific hindrances that interns discussed included disruptive students. Being able to effectively deal with classroom management issues pertaining to disruptive or uncooperative students was a concern for several interns. Connie found using manipulatives in mathematics helped to alleviate student behavior problems:

> Well, I have a really difficult group of students. A lot of them are very disruptive with a lot of talking kids getting out of their seats, people shoving and pushing. It made it hard at times to teach any subject to say the least. One thing about math that is different from the other subjects is that you do have a lot of those hands-on manipulatives you get to use. That would help them to keep them focused and stay busy.

Only one intern expressed concern with students and parents knowing her age. She was terrified that parents would find out how old she was and then exasperate her feelings of incompetence. Andrea stated:

> I did not want kids to know how old I was. I was terrified that parents would find out that it was my first year and that they would make me feel incompetent. So that whole confidence building thing with it being my first year and being so young . . . I am young for my grade so when I started teaching, I was 21 and so that aspect . . . I had a really hard time contacting parents.

Overall, most interns had minimal hindrances preventing them from teaching mathematics. They felt their university training prepared them to teach mathematics and that at least one or more of their mentors provided sufficient support to facilitate a successful internship. Interns who had opportunities to observe other teachers or had mentors that modeled lessons expressed less concern over lack of support and preparation. Paul summed up his internship experience by stating:

> It [My internship] showed me a lot of areas; just how to work with kids. What areas did they need a little more practice in, and be able to see [learn] that [math] over time . . . I don't think that student teaching would have been able to show me that. The internship threw me into that . . . where I had a clean slate and I had not seen anything before . . .

Typically, interns in this study were supported by mentors that emulated Cogan's (1973) mentoring cycle of assistance, where the major components were planning, observing, analyzing, and providing feedback (Reiman & Thies-Sprinthall, 1998).

Discussion

This study addresses interns' perceptions of mentor support for teaching mathematics and teaching skills, factors, and pedagogical behaviors that affected their ability to teach mathematics. Although this study employs a small sample of interns in grades K-8, it provides a snapshot of what interns experience when teaching mathematics and a type of synergy that occurs when the combined efforts of each mentor helps to improve their overall sense of efficacy and pedagogical and mathematical competencies. With the exception of one intern, mentors fulfill a role in developing and "filling in" pedagogical and mathematical deficiencies interns brought to their classroom.

The content knowledge needed for teaching mathematics comprises both 'common' and 'specialized' mathematics knowledge. Both elementary and middle grade interns express difficulty in using 'specialized' mathematics knowledge, especially in representing mathematical concepts in multiple ways and differentiating mathematics instruction for varied learners so that students stay on-task and become independent learners. Some comments made by interns suggest that manipulatives and student-centered learning were implemented in classrooms because interns had difficulties with keeping the entire class on-task and knowing how to direct them during instruction with mathematics-based questions and classroom management.

In comparing Dynak and DeBolt's (2002) descriptions of the roles and relationships that mentors should maintain with their mentees, most interns explain that the various roles of the mentors during their internship help support, facilitate, and challenge them in using effective practices. By providing supportive and committed mentors the foundation is laid for interns to have a successful and rewarding teaching career. Interns describe their mentors as being primarily a facilitator of "instructional improvement and in problem-solving." Interactions between mentors and interns are a combination of both informal and formal observations. The campus mentor engages in more informal observations, the district mentor provides both informal and formal observations and the administrator evaluated interns using a formal observation tool. The district mentor is described by interns as providing the most empathy and assistance in coping with stresses of teaching; with campus mentors providing the next degree of support and other administrators providing the least amount of emotional support.

Hudson and Peard (2005) claim that not enough mentors have the mathematical skills and knowledge to effectively guide and facilitate novice teachers. According to elementary interns, both the campus and district mentors provide them with mathematical support and instruction, such as: (a) modeling lessons and showing alternative mathematics teaching strategies and algorithms; (b) creating and demonstrating how to use mathematics manipulatives; (c) showing how to differentiate mathematics instruction for a variety of learners; (d) developing effective mathematics assessment strategies; and (e) relating mathematical concepts to real-word experiences. However, middle level interns receive most, if not all, of their mathematical mentoring support and instruction from their campus mentor or grade level team who provides them with: (a) ways to develop effective mathematics assessment strategies; (b) mathematics content differentiating for students in different class periods; and (c) alternative mathematics teaching styles and explanations for one mathematics topic. Overall, interns perceived that at least one of their mentors provided them with adequate and sufficient mathematics mentor support and instruction.

Teachers in urban schools are expected to solve problems and deal with situations unique to urban schools. King and Bey (1995) described several conceptions of urban schools, such as perspectives of students, resources, poverty, cultural experiences, and commitment to education and teaching that mentors and teachers in urban schools face everyday. Indeed, interns in this study face many of those same challenges throughout their year-long internship. These interns have a very diverse group of students in their classroom including one with an ESL classroom of primarily Hispanic students. Almost half of the interns express concern and lack of ability to handle classroom management issues, such as students shoving and pushing each other. Several interns describe using student-centered instruction to ensure students have opportunities to move around, sing, and use manipulatives, attempting to keep them on task and focused. Both elementary and middle interns describe their students as either being very high or very low in academic ability with few of their students being in the middle. This complicates lesson planning and differentiating instruction for interns. Lack of resources is another factor that at least two interns expressed as a concern requiring them to purchase their own manipulatives to supplement their lessons. However, as stated by King and Bey, mentoring novice teachers is not a "quick solution" to the problems facing urban schools, but "mentors still play an important role in overseeing the newcomers' entry and retention in the profession" (p. 7).

Typically, interns feel more secure with their teaching of mathematics than they did with the general pedagogical aspects of teaching, such as classroom management, lesson design, and differentiated student instruction. District and grade level campus mentors provide the most mathematics instruction and pedagogically-based support for both groups of interns. Pedagogical support is greatest in the areas of lesson design and implementation of classroom management strategies. The three areas that are most *instrumental* in teaching mathematics are (a) manipulative use; (b) planning of classroom instruction and activities and (c) execution of the lesson. Factors *hindering* interns' abilities to teach mathematics are (a) having to re-learn different algorithms and strategies; (b) limited access to teacher edition adopted textbooks; and (c) lack of funds to purchase manipulatives. These results align with Bartell's (2005) conclusion that varied and multi-faceted elements influence beginning teachers' perceptions about teaching and how their mentors influence those perceptions.

Preparing mentors to guide and develop interns' mathematical instruction and competencies requires more knowledge of how mathematical content knowledge and pedagogical skills are developing within the mathematics classroom. Even though all interns will remain in the teaching profession for the following year, with six of the eleven being retained in the same urban school, it still remains to be seen if they continue teaching in urban schools. One weakness of this study was that it did not continue to track interns' future teaching choices to determine if they remain in urban school settings. This study proposes that due to the dual demand for teachers to improve their understanding and teaching of mathematics and the need to retain high quality teachers in urban schools, more focus and research is needed in the combined area of mathematics teaching and retention in urban schools, especially among elementary and middle level interns.

CHAPTER IV

STUDENT TEACHERS' GENERAL AND CONTENT-SPECIFIC PEDAGOGICAL DEVELOPMENT WITHIN A MATHEMATICS MILIEU

Introduction

Pedagogical proficiency and the capability to implement pedagogical skills in the classroom, greatly influences teachers' abilities to execute and instruct students in subject-matter learning (Darling-Hammond, 2000). The Interstate New Teacher Assessment and Support Consortium Standards (INTASC, 1992) stated that, "teachers need a deep understanding of how mathematical knowledge is developed and how it can be nurtured through well chosen pedagogical strategies" (p. 1). In addition, the National Council of Teachers of Mathematics (NCTM, 2000) has outlined through their standards and principles, the importance of continued learning of mathematical and pedagogical content knowledge. In order to provide and meet these pedagogical and mathematical requirements for pre-service teachers, continued research and understanding of how these factors are inter-related and develop throughout novice teachers' initial teaching experiences is needed.

The purpose of this study is to better understand the content knowledge for teaching mathematics and pedagogical complexities student teachers encounter throughout their initial teaching experience. New teachers leave the profession at an alarming rate negatively effecting student learning (NCES, 2007). Ingersoll (1997) found this was even more apparent for mathematics teachers. This problem needs to be addressed, however, Strawhecker (2005), found there were, "few studies that currently exist to document attempts to integrate mathematics content, pedagogy, and field experiences" (p. 4).

General and Content-specific Pedagogy

An important foundation in mathematics teaching is that teachers have, "common and specialized knowledge" that demonstrates a vast, deep and thorough understanding of mathematics content (Ball, 2001; Ma, 1999). However, being able to teach mathematical content knowledge is intertwined within general and content-specific pedagogy or pedagogical content knowledge (Shulman, 1987).

General pedagogy skills include planning and structuring mathematics lessons, organizing activities, having a system for materials distribution, lesson planning, and motivating students (Fennema & Franke, 1992; Interstate New Teacher Assessment and Support Consortium, 1992). Leinhardt and Smith (1985) described this knowledge as "lesson structure knowledge" that is separate from content knowledge. This knowledge includes skills needed to plan a lesson and lesson transitions from one subject to another. However, general pedagogy skills are not used in isolation but within the context of teaching content-specific instruction, such as mathematics.

Pedagogical content knowledge (PCK) is the combination of both general and content-specific pedagogy into a form of knowledge that is understandable to students. Teachers need to understand representations and organization of the content that is best suited to meet students' needs. The development of teachers' pedagogical content knowledge is influenced by several factors, beginning with content knowledge learned during teacher preparation program and initial teaching experiences (Capraro, Capraro, Parker, Kulm, & Raulerson, 2005). Using both general and content-specific pedagogy in mathematics is especially challenging for student teachers. National, assessment-based standards and principles were created to help guide novice teachers in the formation of mathematics teaching using both general and content-specific pedagogical practices.

Linking General and Content-specific Pedagogy to INTASC Standards

Based on the collaboration of more than 30 states and educational agencies, the Interstate New Teacher Assessment and Support Consortium (INTASC) Standards provided the framework for new teachers in assessing the content-specific and pedagogical knowledge needed to teach essential ideas, processes, and perspectives to students (INTASC, 1992). The ten INTASC Standards are: (1) subject matter, (2) student learning, (3) diverse learners, (4) instructional strategies, (5) learning environment, (6) communication, (7) planning instruction, (8) assessment, (9) reflection and professional development, and (10) collaboration, ethics, and relationships. Standard 1 describes the content knowledge for teaching mathematics based on mathematical ideas, processes, and perspectives and Standards 2-10 describe pedagogical skills and dispositions needed to implement that knowledge. The INTASC Standards are used as a basis for the National Council for Accreditation of Teacher Education (NCATE) teacher licensing and professional development (Darling-Hammond, 1998).

Pedagogical Competencies of Novice Teachers

Novice teachers, such as student teachers, approach and execute pedagogical skills within the classroom very differently than expert teachers. What pedagogical competencies or abilities do student teachers typically bring to their initial teaching experience? Borko and Livingston (1989) reported distinct differences between expert and novice mathematics teachers. First, beginning teachers regarded the classroom as a whole unit rather than being comprised of individual students. When planning instruction, they considered mathematical needs for the whole class rather than for individual students. Second, novices focused on short-term planning with scripted lessons. They planned the types of questions to ask students before the lesson began and had a difficult time answering questions during the lesson that did not relate to pre-scripted questions and maintaining the direction of the lesson after questions were answered. Third, when these beginning teachers were asked to reflect upon their teaching of a mathematics lesson, they focused on the, "clarity of explanations and examples, use of the chalkboard, and ability to respond to student questions" (p. 488). Only one of the novice teachers discussed classroom management effectiveness. Overall, the most common concerns discussed by these mathematics teachers were the amount of time planning lessons and their inability to anticipate student problems. These differences highlighted their limited, "propositional structures for pedagogical content knowledge structures" (p. 490). Borko and Livingston suggested that teacher preparation programs focus more on pedagogical content knowledge and pedagogical reasoning development throughout pre-service teachers' initial teaching experiences. They also recommended the need for increased studies that focused on the development of pedagogical expertise within specific content areas, such as mathematics.

Classroom management is one of the most difficult areas of pedagogical development for novice teachers. Jones and Vesilind (1995) studied the cognitive frameworks for classroom management on student teachers. As they gained experience in managing their classroom, they began to shift their focus from concerns about being the authority figure and students liking them to establishing relationships between classroom management, instruction, and learning. They began to worry less about their own teaching strategies and more about students' learning.

In a study that investigated the nature of pedagogical competency of student teachers, Mapolelo (1999) found that even if student teachers were confident in their mathematical content knowledge, they still had difficulties engaging students in quality discourse, creating meaningful mathematics activities that enhanced student understanding, and lacked the ability to anticipate student misconceptions learning mathematical concepts. Follow up responses to students' answers were typically, "That is good," or "who could help him?" These types of responses were generally encouraging but elicited only low level responses from students. Mathematical explanations were generally clear and accurate, but were procedural, teacher-centered, and did not promote linking mathematical concepts together.

These types of pedagogical competencies are typically experienced by student teachers throughout their initial teaching experiences. Pre-service teachers must transition from the role of student to that of teacher-- learning to develop pedagogical and content knowledge strategies within the classroom. As stated by the National Commission on Teacher and America's Future (1996), in order to teach mathematics effectively, one must combine a profound understanding of mathematics with knowledge of students as learners, and to skillfully choose a variety of pedagogical strategies.

Methodology

Participants

In this study 14 elementary and 6 middle grades pre-service teachers ($N = 20$) were examined throughout their semester-long student teaching experience. All student teacher participants, (pseudonyms are listed in this report), were White and female with the exception of one, Hispanic male. The elementary level student (ELS) teachers taught mathematics daily for approximately 50-90 minutes to extant groups of students. Four student teachers taught kindergarten- (Barbara, Brittany, Jamie, and Mary), one taught first grade (Samantha), three taught second grade (Amanda, Heidi, and Patricia), two taught third grade (Abby and Janet), and four taught fourth grade (Brianna, Fran, Whitney, and Wanda), three taught fifth grade (Faith, Rebecca, and Taylor), two taught seventh grade (Anna and Yazmin) and one taught eighth grade (Richard). The middle level student (MLS) teachers taught mathematics approximately 225 minutes daily (i.e. 45 minutes per class) to five different groups of students, with the exception of the 5^{th} grade teacher, who taught all subjects. Fifth grade is contained in the middle grades certification, however this teacher taught in an elementary school. Student teachers were invited to participate in this study through an invitation by the researcher extended to them during their senior methods courses. Student teacher placements were in districts located in south central Texas, all of which were 2-3 hours from the university in which they were enrolled.

These student teachers met the following requirements prior to participating in their student teaching program: (a) completed their education coursework and field-based clinical experiences; (b) obtained at least a 3.0 grade point average; (c) completed all degree requirements, except for student teaching; and (d) successfully completed all written state teacher certification exams.

The Researcher

The primary researcher for this study developed expertise in assessing student teachers in classrooms on general and content-specific pedagogy by: (a) having 15 years elementary, middle, and university-level mathematics teaching experience; (b) being trained to use the *Classroom Observation and Performance Assessment for Teachers-Revised* (COPAT-R) by the instrument designer; (c) interviewing university-level student teaching program leaders to gain a better understanding of program design and implementation; and (d) having conducted a pilot study using the COPAT on similar groups of student teachers.

Assuming the role of *observer-as-participant* (Johnson & Christensen, 2004), the researcher developed relationships with the student teachers and gathered assessments, self-reports, interviews, and observational data on each participant for nine months, beginning in the final year of their teacher preparation program and continuing until the conclusion of his/her student teaching experience. However, this report focuses on the student teaching period. Additionally, she met with student teachers three times in their classrooms. During the first visit, the format of the study was reviewed with the student teacher; the mentor and/or other supervisors were met; the student teacher described classroom compositions and routines; and other preliminary items were discussed. The format of the next two visits involved the formal observations using the COPAT-R. The researcher only observed mathematics lessons that student teachers taught. Due to experiences during the researcher's pilot study, detailed notes and audio recordings were collected during observations rather than attempting to simultaneously complete the COPAT-R while observing the lesson and taking notes. Worksheets used by students during the lessons, lesson plans, classroom seating diagrams, and lesson audiotapes were also used to triangulate findings. The student teachers and researcher also engaged in member check and informal interactions through phone conversations.

Research Questions

To examine and compare general and content-specific pedagogical skills of ELS and MLS teachers, the following research questions framed this study. (1) What trends in general and content-specific pedagogical behaviors, resulted in ELS and MLS teachers' pedagogical development such as: a) instructional preparedness, b) instructional environment/classroom management, c) format and structure of instructional content delivery, d) instructional monitoring, and e) motivation and feedback, in teaching mathematics? (2) What self perceptions of general and content-specific pedagogical skills did student teachers possess? (3) What were the most important differences between general and content-specific teaching behaviors evident between the researchers' external observations and student teachers' self perceptions?

Instrumentation

COPAT. The COPAT© was used to observe and assess general and content-specific pedagogical teaching behaviors. The five COPAT domains were: 1) instructional preparedness, 2) instructional environment/management, 3) instructional lesson, 4) instructional monitoring, and 5) instructional motivation and feedback. The COPAT was designed using the INTASC Pedagogy Standards (1992), North Carolina Teacher Performance Appraisal System, and the Danielson (1996) instructional framework. The COPAT included descriptors that were not empirically or numerically used to obtain overall domain scores. Therefore, the training to use the instrument included watching video of teaching, discussions of descriptor enactments, and then determining an overall domain score. In addition to these numerical ratings “1-10” for each domain, qualitative descriptions pertaining to each descriptor and domain as enacted were also collected.

From the pilot study, issues related to the validity and reliability of the data collected from the COPAT became apparent. First, providing a score of 1-10 for each domain was based on an arbitrary impression of the domain descriptors. The descriptors within each domain were scored using symbols, such as positive (+), mixed (M), keeping working (K), or negative (-). However, no numeric value was assigned to each of these symbols in determining a domain score. For example, there was no benchmark governing the number of (+), (M), (K), and (-) that would yield any specific numerical rating. After each descriptor was given a rating, +, M, K, or -, the rater would assign the domain a score (1-10) based on impressions or subjectivity of proportions of each +, M, K, or - symbols received. Another concern was the misalignment or a poor fit between some COPAT domains and their descriptors. The instrument was adjusted to value each descriptor as contributing to the domain score and the descriptors and domains were aligned to much better match the theoretical construct embodied in each domain.

Therefore, the instrument was reconfigured using a face validity technique of expert consultation and reconciliation. The first expert examined factor groupings from exploratory factor analysis[12] (EFA) results and made a decision to either keep the descriptor in its current domain, or move it to a more appropriate domain. The other expert, independent from the first also reassigned descriptors based on experience and knowledge of the constructs. Using the model for cognitive interviewing that followed the caveats outlined by Beatty (2004), with special consideration to avoiding influencing responses; both experts reconciled their reorganized COPAT domains agreeing on 14 of the 16 reassigned descriptors resulting in an 88% agreement. For example, descriptors, such as “students on task quickly” and “high level of time on task” did not seem to fit within the domain, instructional preparedness (IP), therefore were moved to the instructional environment/management (IEM) domain. Also, the instructional lesson (IL) domain contained descriptors that focused on both general and content-specific skills,

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[2] An exploratory factor analysis (EFA) was conducted to determine how many factors would emerge to produce a more accurate model to better align descriptors within each of the COPAT domains (Henson, Capraro, & Capraro, 2004). An analysis of the principal components analysis (PCA) correlation matrix using 60 descriptors from the COPAT yielded 17 components with eigenvalues > 1and the scree plot indicated at least seven components. In order to obtain a more parsimonious and replicable solution, a Varimax with Kaiser Normalization rotation method extracted and rotated these seven components, which accounted for 60% of the observed variance. Results found that most skills were highly saturated on the first six factors that had eigenvalues of 3.0. In order to verify saturation of factors, an independent validation check between two researchers was conducted to compare configuration of skills within each domain. After reconciliation of results was completed, reliabilities were computed for the newly formed domains, resulting in six factors.

such as the descriptor “content information accurate”. As a result, a separate domain, instructional content (IC), was created using descriptors from the instructional lesson domain. The COPAT-R instrument was used because the researcher believed it would yield more valid domain scores (See Appendix C).

Therefore, the COPAT-R differs from the COPAT, in that there are six domains total measured by the 60 descriptors, five general pedagogical domains: instructional preparedness (IP), instructional environment/management (IEM), instructional lesson (IL), instructional monitoring (IM), instructional motivation and feedback (IMF) and one instructional content domain (IC), a content-specific pedagogical domain.

Administration of the COPAT-R. The COPAT-R was used on a pre and post test basis. Pretest data were collected during the 5th and 6th weeks of student teaching, representing the inception of the student teachers’ full time teaching responsibilities. Posttest data were collected during the 11th and12th weeks, representing the final two weeks of the student teachers’ full time teaching responsibilities.

The pretest *Cronbach’s alpha* reliability estimates for ELS and MLS teachers on each domain (IP, IEM, IL, IC, IM, IMF) was .66, .91, .84, .70, .82, and .90, respectively, with a combined reliability for all six domains of .96. Similarly, the posttest *Cronbach’s alpha* reliability estimates for both groups on each domain were .55, .88, .66, .43, .79, and .86, respectively, with a combined reliability for all six domains of .93. *Cohen’s kappa* reliability between the researcher and another rater trained in using the COPAT-R was found to be .40, indicating moderate agreement (Viera & Garrett, 2005).

The structure of the COPAT-R did not change the qualitative component of the COPAT. Qualitative data collected on the COPAT-R included written notes and descriptions for each domain gathered during lesson observations. These notes helped to clarify and explain results from the quantitative analysis used to compare COPAT-R domain factors on certification level.

Student teacher interviews. Data were collected using audio-taped, summative semi-structured interview questions. The interviews were completed during the 12^{th}-13^{th} week of student teaching. The duration of the interviews lasted an average of 45 minutes. The 10 questions focused on general and content-specific pedagogy. The interview question structure were designed as conversation starters and not intended to be all encompassing. This semi-structured interviewing technique (Seidman, 2006) was designed to provide insights while allowing for flexibility in probing participants for details about their perceptions. Even though each question was asked to all participants, the researcher allowed them to expand upon answers, as desired.

Analytic Design

Mixed methods. A mixed method, concurrent triangulation strategy was used to confirm, cross-validate, and corroborate the findings of two quantitative and two qualitative instruments used within a single study (Creswell, 2003; Tashakkori & Teddlie, 1998) (See Figure 2). The rationale for mixing methods was to: a) ensure instrument fidelity by explaining within and between participant variations in outcomes from the quantitative and qualitative instruments used on both groups (i.e. ELS and MLS teachers) and b) ensure “significance enhancement” by expanding the results of the quantitative data with the qualitative findings through the use of a concurrent triangulation strategy (Creswell, 2003; Onwuegbuzie & Slate, 2007). Integration of data was converged at the end of student teaching (data from the COPAT-R and summative interviews). This triangulation strategy was chosen to report results accurately and comprehensively (Onwuegbuzie & Leech, 2005).

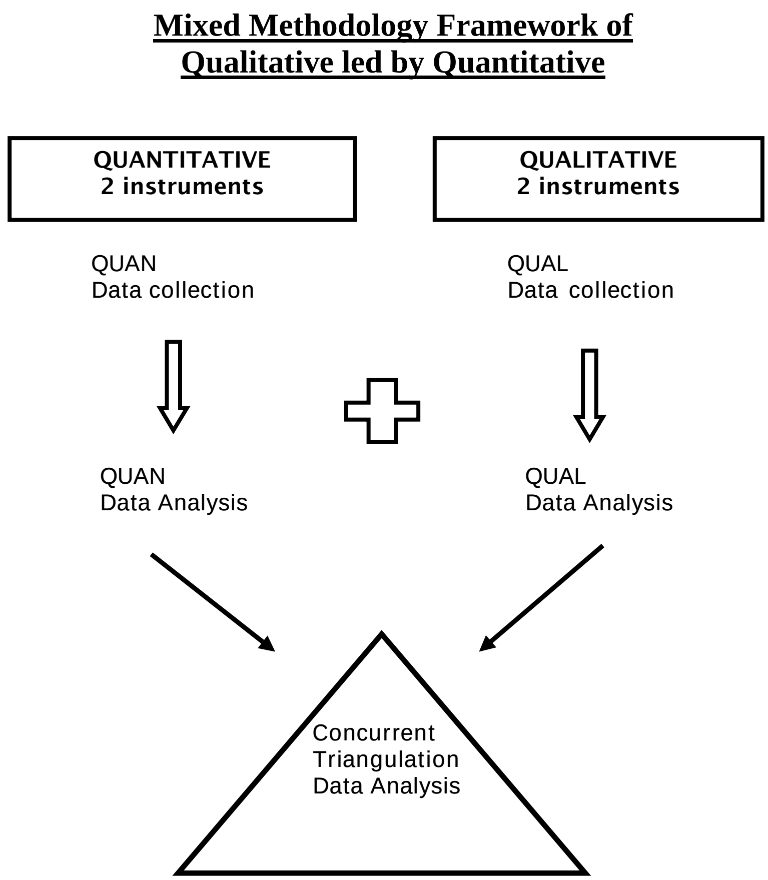

Figure 2. Concurrent triangulation strategy.

Interview questions. The analysis used for interview data grouped interview responses by certification level (elementary and middle) and general and content-specific domain type (See Appendix D). Student teachers were asked to select and explain which COPAT-R descriptors they perceived as either being competent in or lacking from his or her repertoire. The researcher did not require each descriptor be ranked, but allowed participants to select descriptors within each domain in which they felt they were most and least competent. An emergent design was employed to examine common themes or ideas as they developed throughout the organizing and examination of data. Patterns in responses were used to group chunks of data into interpretable categories. Trustworthiness was established by: (a) collecting thick descriptions in the interviews, (b) engaging both the student teacher and researcher as conversational partners, (c) conducting a pilot study that examined pedagogical factors of former student teachers using classroom observations, and (d) consulting with mentoring and mathematics education experts.

Quantitative analyses. The researcher calculated the total number of most and least competent occurrences from the interview perceptions selected by ELS and MLS teachers for each descriptor. Differences between groups for each level (most and least competent) were ranked according to largest descriptor differences for each domain. During the coding process each descriptor was given a frequency occurrence of one, each time it was selected by a student teacher. Because the number of participants in the two groups of student teachers was not equal and they could select more than one descriptor within a domain the number of occurrences were reported as a percentage of the total in that domain. For example, if 7 out of the 14 ELS teachers selected a descriptor it would be reported in the table as 50% ($7 \div 14 = \frac{1}{2} = .50$). Transcribed dialogue and explanations for descriptors with the greatest differences between percentages were included to provide a rationale that supported student teachers' self-report perceptions of their general and content-specific pedagogical development.

The COPAT-R descriptors were scored using the following scale: (a) a score of 4 was given when an occurrence was observed accurately and consistently throughout the lesson; (b) a score of 3 was given when an occurrence was satisfactorily observed but not consistently used throughout the lesson; (c) a score of 2 was given when the descriptor was evident but not consistent in application; and (d) a score of 1 was given when the descriptor was not appropriately evident during the lesson. Because one goal of the study was to determine if ELS and MLS teachers differed on general and content-specific pedagogical domains, the descriptor scores, one through four, were averaged on each domain, resulting in factor scores. Pre and post factor scores were calculated for statistically significance differences for both groups and were measured using both an analysis of analysis of covariance (ANCOVA) and multivariate analysis of covariance (MANCOVA) approach. The six pre-test factors were included as covariates to control for the effects of the pretest factors on the post test factor results.

Interview Results

Using a constructivist theory (Denzin & Lincoln, 2003), the researcher examined how student teachers constructed and developed their general and content-specific pedagogies throughout their student teaching experience. Through interviews based on the COPAT-R, the researcher gained an understanding of self-perceptions ELS and MLS teachers had concerning their general and content specific pedagogical development. Table 14 contains a summary of this information.

Table 14

General and Content-Specific Pedagogy Descriptor Competencies

Domains	Descriptors	% **Most** Competent			% **Least** Competent		
		ELS	MLS	% Δ	ELS	MLS	% Δ
IP	**System for materials distribution**	14	50	**36**	21	0	**21**
	Lesson plan ready	50	17		7	17	
	Selects instructional goals	36	17		7	17	
	Percentage total	100	84		35	34	
IEM	Routines are identified/evident	50	17		7	0	
	Inappropriate behavior handled effectively	14	17		29	67	**38**
	Consistent application of rules	14	67	**53**	36	17	
	Minimal disruptions to class	0	0		50	17	
	Students on task quickly	14	17		71	33	
	High levels of time on task	0	17		43	67	
	Students engaged productively	14	0		29	0	
	Prevention techniques used	0	0		29	33	
	Materials ready	57	83		0	0	
	Necessary items available	50	50		7	0	
	Sets reasonable work standards	50	17		7	7	
	Assigns independent practice	43	33		7	7	
	Percentage total	306	318		315	268	
	Objective, purpose and intent clearly presented	29	17		0	17	
IL	Lesson initiation; interesting, compelling	7	0		0	17	
	Speech, fluent, clear	14	50	**36**	7	0	
	Directions clear and precise	36	50		7	0	
	Transitions, smooth	7	0		21	17	
	Interactive	21	17		7	0	
	All parts of lesson tie together	7	0		7	0	
	Lively/appropriate pace	29	0		14	17	
	Student reflection included	0	0		21	0	
	Engagement, equitable	7	0		0	17	
	Closure included	29	0		14	50	**36**
	All critical lesson components evident	7	0		0	0	
	Lesson modifications made, if needed	14	17		21	17	
	Lesson culturally responsive	0	0		7	0	
	Objective met	29	17		0	17	
	Student seating supports lesson	29	17		14	17	

Table 14 Continued

Domain	Descriptors	% **Most** Competent			% **Least** Competent		
		ELS	MLS	% Δ	ELS	MLS	% Δ
	Strategies, varied	14	0		29	0	
	Examples relevant	14	17		0	0	
	Percentage total:	293	202		169	186	
	Prior knowledge point of reflection	0	0		7	0	
IC	Strategies, developmental (age appropriate)	7	0		7	0	
	Strategies, adjusted as needed	0	0		0	0	
	Questions (open, varied levels)	14	0		14	33	
	Lesson has core integration	0	0		0	0	
	Critical thinking encouraged	0	0		29	17	
	Content information accurate	0	17		0	0	
	Student centered	36	0	**36**	21	0	**21**
	Total:	57	34		78	50	
	Monitoring occurs	50	17		14	17	
IM	**Circulates to check performance**	29	83	**54**	14	0	**14**
	Checks progress frequently	50	50		14	17	
	Checks both whole class and individual	21	0		29	17	
	Stands/sits to see all students	21	0		14	0	**14**
	Frequent visual scanning	50	17		0	0	
	Immediate feedback on work or answers	21	33		21	33	
	Confirms correct answers	14	17		14	17	
	Uses informal or formal assessments	14	0		14	0	**14**
	Percentage total:	270	217		134	101	
IMF	**Effective motivation techniques used**	36	0	**36**	7	10	
	Sustains feedback with incorrect answers	36	17		14	17	
	Appears enthusiastic	43	67		7	0	
	Respectful and valued responses	50	67		0	0	
	Positive climate in classroom	36	50		7	0	
	Students appear motivated	14	0		29	0	**29**
	Responsive to student questions	21	0		7	0	
	Receives oral/written data	7	0		7	17	
	Provides guided practice	29	0		14	33	
	Percentage Total:	272	201		92	84	
	Percentage total for all 6 domains	1,298	1,056		823	723	

Note. Descriptors in bold indicate items with the largest difference between the ELS and MLS self-evaluation rating. Percentages within domains do not sum to 100% because participants could have selected more than one descriptor for each more or less competent category.

Instructional Preparedness (IP)

Perception of most competent descriptors. The MLS teachers felt more competent (50%) than ELS teachers (14%) for having a *system for materials distribution* while, ELS teachers felt more competent in *having lesson plans ready* (50%). Janet explained how the lesson plan helped organize her day.

> I realized that if you don't have it [lesson plan] together it is like flying by the seat of your pants . . . and that is crazy! . . . when you come into the classroom . . you don't know what's going to happen next. You just can't make short hand notes or at least I'm not ready to do that yet. I need times and everything planned out.

In comparison, Anna taught the same lesson to five different groups of students each day. Even though she had her lesson plan, she noticed fluctuations following her lesson plan with each subsequent class.

> I tried to be prepared, whereas I can see now that the first class would get the [most] mistakes . . . just me learning through my mistakes with the lesson plan helped me to realize that I need to go over it a few more times [before teaching it to students].

Perceptions of least competent descriptors. The ELS teachers felt least competent (21%) than MLS teachers (0%) for having a *system for materials distribution* while, MLS teachers felt least competent in *having lesson plans ready* (17%) and *selecting instructional goals* (17%). Amanda explained a frustration she experienced when asking students to assist with distribution of materials. Amanda stated "lately I have been asking whoever is ready or whoever is quiet to pass out papers . . . but I don't like so many students [walking] around the room because it gets them off task and they'll start talking to whoever they're passing the papers to."

Instructional Environment/Management (IEM)

Perceptions of most competent descriptors. The MLS teachers felt more competent (67%) than ELS teachers (14%) for having a *consistent application of rules* while, ELS teachers felt more competent in having *materials ready* (57%). Taylor's approach in being consistent with rules was similar to the statements of two other MLS teachers. She stated, "The students know what to expect from me and they know that if they choose to break a rule it be consistent with the consequence . . . I won't vary my rules according to what mood I am in."

ELS teachers felt having materials ready was especially important when using manipulatives and to help keep students on-task. Anna stated that, "if you don't have your materials ready, you're going to have a hard time with classroom management and just getting through the lesson."

Perceptions of least competent descriptors. The MLS teachers felt least competent (67%) than ELS teachers (29%) for *handling inappropriate behavior effectively,* while, ELS teachers felt least competent in *having students on task quickly* (71%). Anna felt that she gave students too many chances for students to misbehave and was ineffective at stopping the misbehavior before it got out of control.

> I think that I give too many chances because I am young. I don't want to come across as mean . . . I just kinda blow it [the misbehavior] off for a while until it really becomes a problem. Where, if I could nip it in the bud at the beginning, then it wouldn't become one.

Student teachers also described how difficult it was keeping students on task and focused when learning mathematics and completing assignments. Samantha stated, "If you give them [students] manipulatives, you have to make sure they are really listening and using them as tools rather than as play toys." Sometimes the scheduling of mathematics classes during the day can make it hard to keep students on-task. Abby stated that,

> keeping the students on task quickly has been a struggle, especially in math because our math time is right after lunch . . . they go the restroom and they come into the room all excited . . . then keeping them on task for the whole hour of math . . . and they know that at the end of math is recess. So they are excited coming back from lunch and about halfway through math they realize they have recess in 30 minutes so they get excited about that.

Instructional Lesson (IL)

Perceptions of most competent descriptors. The MLS teachers felt more competent (50%) than ELS teachers (14%) for having *fluent, clear speech* while, ELS teachers felt more competent in *having a lively appropriate pace* (29%) and *providing lesson closure* (29%). Anna felt that she was loud and clear and had good speech fluency. Faith also felt that she spoke well and students could understand her directions. Several MLS teachers stated that it was important to speak clearly and accurately because students only had 45-50 minutes in class and so they did not have a lot of time for restating directions again.

Perceptions of least competent descriptors. The MLS teachers felt least competent (50%) than ELS teachers (14%) for having *lesson closure* while, ELS teachers felt less competent in having *varied strategies* (29%). MLS teachers felt least competent when providing closure to a lesson. Taylor explained how she always felt rushed at the end of the lesson.

> I always feel rushed and the students are thinking "why are we doing this? I would rather just move on to the next activity." I would like to not be so repetitive but actually sum up the lesson and have it interactive so students can

> answer questions. Sometimes it is a good idea to restate the purpose and objective of the lesson to help students know why they just spend an hour learning this skill and how it is going to help them in their lives.

Faith described closure as a time management issue.

> Closure is a struggle because it's not that I don't know what to say. It's more about time management and has been a huge lesson for me to learn. Ok, I have to get this done but I really only have this amount of time. So, that's my worst enemy all day is time. Closure kinda gets pushed aside even though I know it is real important.

Brittany said one reason she used the same strategy of using manipulatives, such as unifix cubes, is because her mentor did not have a good variety of resources. Amanda reflected that she would like to use more student-centered strategies in mathematics, such as working in groups or in centers, but is afraid of losing control of students. "Sometimes I wish we could do more where they break up into groups, like more center things. I just feel like I would lose control of the classroom . . . I've done games before and it got very loud."

Comparison of Instructional Content (IC)

Perceptions of most competent descriptors. The ELS teachers felt more competent (36%) than MLS teachers (0%) for having *student centered instruction* while, MLS teachers felt more competent in teaching *accurate content* (17%). Patricia used student-centered instruction to keep students on-task and motivated. "I try to involve the students as much as I can so they can respond to questions, and not just me blabbing my mouth. I want students to be involved and motivated."

MLS teachers felt better prepared to use accurate content information when teaching mathematics. Anna expressed the importance of how lesson planning can help in teaching accurate content. "I've learned to mix that [mathematics content] up and make sure I know what I am doing. I usually try to work the problems out and figure out the answers before I get up there [in the classroom]." She also stated why it was important for students to have an in-depth understanding of mathematics content.

> I ask a lot of "whys" [questions] . . . you can memorize math, but I want them to understand why, and where the concept is coming from because . . . we are seeing this on the TEKS [Texas Essential of Knowledge and Skills]. The [students] know the material for school, but when it comes to reading and having to actually comprehend and use those math content skills, that's missing. So, when we are finding the square root, what does square root mean? Or if I am doing Pythagorean Theorem . . . why does this theorem work? I try to make it so they have to think a little bit. I am not just completely giving them the answer.

Perceptions of least competent descriptors. The MLS teachers felt least competent (33%) than ELS teachers (14%) for asking questions at open, varied levels while, ELS teachers felt least competent in encouraging critical thinking skills (29%). Faith described the difficulties of using varied levels of questions when teaching mathematics.

> I really want to work on my questioning skills. I think that I can get to the lower levels but I want to work on the high levels. After we learned the area of a rectangle we tried to derive the area of a triangle . . . by starting off with identifying polygons. [Questions asked were] "Why do we all agree they are all polygons?" What kind of polygons are they?" I was really surprised by some kids' answers. One [special needs] boy said a really great thing . . . two triangles can fit together with another one to make a rectangle.

Faith was pleasantly surprised that asking higher level questions to varied levels of students provided the potential for all students to learn and understand mathematics concepts.

Comparison of Instructional Monitoring (IM)

Perceptions of most competent descriptors. The MLS teachers felt more competent (83%) than ELS teachers (29%) for *circulating to check performance* while, ELS teachers felt more competent in *monitoring students* (50%) and *frequent visual scanning* (50%). Anna believed she encouraged her students by walking around while they completed seatwork.

> . . . circulating to check performance is something I really try to do and my legs will tell you the same thing. I get finished at the end of the day and I haven't sat down all day. I try to stand and keep moving because I think it is encouraging them. I think that if I go sit down, they may get off task.

Amanda described how she used her physical presence to circulate and check student performance. " . . . I tried to walk around a lot . . . and sit on someone's desk that is talking. I tried to not do as many verbal reprimands so I would just touch them or whisper in their ear if they are off task. I am always walking around and looking at them [students].

Perceptions of least competent descriptors. The ELS teachers felt least competent (14%) than MLS teachers (0%) for *circulating to check performance*, *stands/sits to see all students*, and *using informal or formal assessments*, while, MLS teachers felt least competent in *providing immediate feedback on work or answers* (33%). Janet felt that she did not need to circulate because there were several teaching assistants in the classroom. "I definitely need to circulate more. I guess that I am kinda spoiled because we have so many aids in the classroom. I feel safe in front of the room since there are aides and helpers by the students." Mary used mathematics centers for instruction but had a difficult time circulating to all centers.

> It was hard to circulate and sit at the teacher table [teaching her group of students]. That really frustrated me because so many of my students [from other centers] kept coming to my table and saying "how do you do this . . . I wasn't really listening to them [because I was teaching]. It was hard to keep my group of students on task because I had so many other students coming up to me the whole time.

Samantha stated that she needed more experience with informal practice because most of their mathematics assessments used formal assessments. Conversely, Brittany felt that she needed more practice administering formal mathematics assessments because her class did not complete assessments, other than journals.

The lack of ability of MLS teachers to provide immediate feedback was sometimes a result of the large amount of papers that needed to be graded and returned to students. Taylor felt that,

> if they turn in a worksheet, then sometimes it can take me a couple of days to return it to them. So . . . it leaves them still wondering . . . they are wanting some type of follow up to know they did the questions correctly, especially if one was a difficult problem solving question. Sometimes students come to me at recess and want to get feedback on their papers.

Comparison of Instructional Motivation and Feedback (IMF)

Perceptions of most competent descriptors. The ELS teachers felt more competent (36%) than MLS teachers (0%) for *using effective motivation techniques* while, MLS teachers felt more competent in *appearing enthusiastic* (67%) and *being respectful and valuing student responses* (67%). Samantha stated that an effective motivation technique was using manipulatives during mathematics instruction. "They [the students] got really excited about using manipulatives in math class." Amanda used a classroom management money system to motivate students. Most motivational techniques were extrinsic rather than intrinsic.

Brianna hoped that her “children knew their answers were respected and appreciated in the classroom.” She wanted them to “enjoy being in the classroom, where it is a safe environment and where their answers and learning were respected.” Anna also wanted her students to enjoy mathematics as much as she did. “I love math and I want them to love the class. I know we go through the same process everyday but sometimes I’ll try to change it up.”

Perceptions of least competent descriptors. The ELS teachers felt least competent (29%) than MLS teachers (0%) for *motivating their students,* while MLS teachers felt least competent (33%) than ELS teachers (14%) for *providing guided instruction*. Whitney explained that motivating all students can be a challenge. “. . . some of them are fine [to motivate] and want to do their work but there are a few that have no motivation and trying to find ways to motivate them is hard.” Brianna realized that students are not motivated to learn because of the influences of personal issues. “It’s amazing how much home life affects their [motivation]. Samantha said that she used manipulatives during mathematics to motivate students. Most student teachers described using extrinsic motivation techniques to motivate engage and retain students’ attention.

MLS teachers felt least competent to provide guided practice for students. Faith described the perils of providing guided practice. “I lose some kids during guided practice. I really talk to them a lot about raising their hand and realizing . . . there are times where you don’t know [if they are understanding]. Taylor stated that sometimes she does not realize students need more guided practice until they begin working on their independent seat work. “Sometimes I think that they are ready for independent work [after doing guided work together] but then about ten of them would say, "I can't do the work." I realized that oops, I had them jump into that [independent work] too quickly. We needed more practice together, first."

COPAT-R Results

Quantitative results from COPAT-R examined trends in general and content-specific pedagogical skills resulting in differences between ELS and MLS teachers' general and content-specific pedagogy development. Since neither MANCOVA nor ANCOVA results were significant due to low power, standardized residuals scores from ANCOVA were saved and a nonparametric sign test was conducted on certification level to determine directional effects. Statistically significant results (p <.05) from the sign test on each of the residual scores indicated groups improved from pre to post on each COPAT-R domain. In addition, mean differences between the two groups on each factor were used to determine directional effects and determine which group improved most on each of the general and content-specific pedagogical domains. The ranking of mean differences showed that MLS teachers slightly outperformed ELS teachers on all six domains, with highest mean differences in the IP domain, $\overline{X}_{Post} = 0.59$ ($\overline{X}_{elementary} = 2.02$, $SD = .84$; $\overline{X}_{middle} = 2.61$, $SD = 1.1$), and IEM domain, $\overline{X}_{Post} = 0.43$ ($\overline{X}_{elementary} = 3.01$, $SD = .62$; $\overline{X}_{middle} = 3.44$, $SD = .43$), followed by the IMF domain, $\overline{X}_{Post} = .31$ ($\overline{X}_{elementary} = 3.00$, $SD = .61$; $\overline{X}_{middle} = 3.31$, $SD = .33$), IL domain, $\overline{X}_{Post} = .18$ ($\overline{X}_{elementary} = 2.56$, $SD = .37$; $\overline{X}_{middle} = 2.74$, $SD = .20$), IC domain, $\overline{X}_{Post} = .10$ ($\overline{X}_{elementary} = 2.52$, $SD = .38$;

$\overline{X}_{middle}$ = 2.62, *SD* = .41), and IM domain, $\overline{X}_{Post}$ = .07 ($\overline{X}_{elementary}$ = 3.04, *SD* =.63; $\overline{X}_{middle}$ = 3.11, *SD* = .44) (See Table 15).

Table 15

COPAT-R Descriptive Statistics and Mean Differences

Factor	Certification Level	$\overline{X}$	*SD*	*N*	$\overline{X}\Delta$
IP	1	2.02	.84	14	
	2	2.61	1.1	6	.59
	Total	2.20	.94	20	
IEM	1	3.01	.62	14	
	2	3.44	.43	6	.43
	Total	3.14	.59	20	
IL	1	2.56	.37	14	
	2	2.74	.20	6	.18
	Total	2.61	.33	20	
IC	1	2.52	.38	14	
	2	2.62	.41	6	.10
	Total	2.56	.38	20	
IM	1	3.04	.63	14	
	2	3.11	.44	6	.07
	Total	3.06	.57	20	
IMF	1	3.00	.61	14	
	2	3.31	.33	6	.31
	Total	3.09	.56	20	

Note: 1-Elementary level, 2-Middle level

Results from mean differences on certification level support that MLS teachers outperformed ELS teachers on all six pedagogy domains. These differences suggested that there were specific descriptors within domain factors that influenced or affected group differences. The largest differences between the groups were in the IP and IEM domains, which showed that MLS teachers were more prepared to teach mathematics and displayed better classroom management ability than ELS teachers. However, how did these results compare to the student teachers' self-report perceptions on pedagogical development?

Triangulation of Interview and COPAT-R Results

A mixed-methods concurrent triangulation strategy (Johnson & Christensen, 2004; Tashakkori & Teddlie, 1998) was employed to corroborate the consistency of findings from two qualitative and two quantitative instruments on ELS and MLS teachers. Triangulation was used to increase validity of results and control threats influencing results from both the interviews and COPAT-R (Onwuebuzie & Johnson, 2006).

The largest mean differences between the groups were in the IP and IEM COPAT-R factors, in favor of MLS teachers. Because of these findings, triangulation was undertaken to compare and corroborate the findings of the researcher's in-class observations and student teachers' self-perception interview results. Therefore, the purpose of the triangulation was to determine if MLS teachers were better prepared and demonstrated more effective classroom management skills, in comparison to ELS teachers?

Instructional Preparedness (IP)

Mean differences from the COPAT-R indicated MLS teachers possessed a higher mean score, $\overline{X}_{middle} = 2.61$, $SD = 1.10$, than ELS teachers $\overline{X}_{elementary} = 2.02$, $SD = .84$. A comparison of these mean differences with self-perception interview results found that the ratio of most competent to least competent descriptors for MLS teachers was 5:2 and for ELS teachers was 14:5. These results indicated that ELS teachers were slightly more competent across the descriptors within the IP domain, thus not corroborating with COPAT-R results.

Instructional Environment/Management (IEM)

Mean difference results from the COPAT-R indicated MLS teachers had a higher mean score, $\overline{X}_{middle} = 3.44$, $SD = .43$, than did ELS teachers $\overline{X}_{elementary} = 3.01$, $SD = .62$, on the IEM domain. A comparison of the mean difference results with the self-perception interview results found that the ratio of most competent to least competent descriptors for MLS teachers was 19:16 and for ELS teachers was 43:44. These results indicated that MLS teachers generally felt more competent across the descriptors within the IEM domain, thus corroborating mean difference results.

Overall, triangulation of COPAT-R and interview results found that group mean differences supported student teacher developmental perceptions from interviews on the IEM domain but not on the IP domain. In general, both the researcher and student teachers perceived that MLS teachers demonstrated more competency than ELS teachers in the IEM domain. In contrast, the researcher perceived MLS teachers more competent in the IP domain than did the student teachers.

Discussion

This study found that MLS teachers demonstrated higher general and content specific pedagogical competencies than ELS teachers, with largest mean differences within the instructional preparedness (IP) and instructional environment/management

(IEM) domains. Both the researcher and student teachers felt that MLS teachers demonstrated increased competency in the IEM domain. In contrast, the researcher felt that MLS teacher's demonstrated higher competency than ELS teachers in instructional preparedness, whereas ELS teachers perceived themselves as more competent than MLS teachers. A few reasons why the researcher felt MLS teachers demonstrated higher general and content specific pedagogical competencies was because: 1) MLS teachers selected the mathematics class in which the researcher observed them, 2) the cooperating teacher was present during lessons more often than ELS cooperating teachers, 3) MLS teachers planned and prepared fewer classes, and 4) they only taught mathematics and not several other subjects, as did the ELS teachers. Typically, MLS teacher would invite the researcher to observe them in well-behaved and/or academically advanced classes. This made it more likely for them to maintain effective classroom management, organize and execute the lesson with minimal student interruptions, and therefore receive higher IEM domain scores. Whereas, in elementary school, the classroom student composition did not change throughout the day so ELS teachers typically taught the same group of students for the entire day.

Further examination of the IC domain found there were group similarities demonstrated in content knowledge for teaching mathematics. First, both ELS and MLS teachers primarily used procedurally-based teaching strategies during instruction. These findings align with Mapolelo's (1999) conclusion that mathematics lessons were generally procedural-based. In this study, use of conceptually-based teaching was evident only in one kindergarten and one seventh grade student teacher's mathematics classroom. These two student teachers generally asked higher-order questions, engaged students in longer, more in-depth discourse, and were able to guide students through effective questioning strategies to understand mathematical concepts. However, these were not used in the majority of mathematics classrooms among both groups of student teachers. Second, both groups of student teachers used manipulatives to facilitate mathematics instruction but did not incorporate them into the actual teaching of the lesson. Lessons were generally taught using the overhead or chalkboard with student teachers calculating mathematical algorithms and steps to solve mathematical problems. Manipulatives were used by students after the lesson was taught to aid in completing worksheets or activities that reinforced recently learned mathematical skills or concepts. The most effective use of manipulatives in teaching concepts were seen by kindergarten teachers during "calendar time" when both teacher and student would use clocks to tell time; place value sticks to trade ones, tens, and hundreds; hundreds chart to skip count by 2's, 5's, 10's, and a calendar to show linear and non-linear patterns. Third, a combination of student-centered and teacher-centered instruction was demonstrated by both groups of student teachers. This is contradictory to Mapolelo's (1999) study, in which student teachers used primarily teacher-centered instruction. Finally, both groups demonstrated mathematical content proficiency by using accurate mathematics strategies and algorithms. Occasionally, incorrect terminology, such as ounces instead of pounds, were stated but overall skills and concepts were taught mathematically correct and accurate mathematical terminology were used in lessons.

Through observations of mathematical lessons, student teachers demonstrated a solid understanding of mathematical content. However, it was more difficult to teach this content until these beginning teachers gained better control and proficiency in utilizing pedagogical strategies. As found in Jones and Vesilind's (1995) study of classroom management, this area of pedagogical competency was difficult for both groups of student teachers to maintain. The ELS teachers felt least competent to get students on task quickly and to minimize classroom disruptions. Similarly, the MLS teachers felt least competent to handle inappropriate behavior effectively and engage students in high levels of time on task. Where student teachers in Jones and Vesilind's study worried less about their teaching strategies and more about students' learning by the end of student teaching, the majority of student teachers in this study were still focused on improving their pedagogical and mathematical competencies and teaching strategies. They were more focused on improving their own teaching skills, such as planning lessons, developing questioning and classroom management techniques, than on their students learning of mathematics. As Borko and Livingston (1989) found in their study, during classroom instruction, they viewed the classroom as a whole unit, rather than focusing on individual student learning. During observations, it was obvious to the researcher that they stuck to scripted lessons and questioning techniques and seldom varied in their pre-planned goals and objectives. Only Barbara and Anna showed the ability to focus on individual students' learning of mathematics during group instruction using conceptually-based teaching strategies. In member check discussions with the researcher, they discussed how they would modify student questions and re-direct instruction to meet the needs of students as they occurred. The researcher also observed these types of teaching skills in the classroom. For example, Barbara began her lesson by passing out inter-linking cubes and black work mats to students. She led students through an imaginary journey to a zoo where they began to add and subtract using the interlinking cubes as animals and mats as animal cages. After adding or subtracting animals together, she asked students to explain what they had just calculated and to compare computations in one problem to computations in another. After several of these types of guided practice examples using the interlinking cubes to add and subtract whole numbers, students were then encouraged to lead the class in creating their own word problems using the interlinking cubes (i.e. zoo animals) as manipulatives. However, if students answered a problem incorrectly or had difficulty understanding a question, Barbara spent time guiding and probing the student to determine their level of understanding. While doing this, she was able to keep the rest of the class focused on the discourse between her and the other student and would often bring other students into the conversation. Questions were regarded as avenues for further investigation instead of delays in completing the lesson. They were not constrained by the dictates of planned lessons and questions but felt secure enough with their own knowledge of teaching and their students' mathematical needs to alter from the prescribed lesson, if needed. Again, this was not typical of the other student teachers' instructional delivery and format. Common responses to indirect or unexpected questions from students were polite but brief answers in an attempt to redirect them to the curriculum being taught. The researcher even observed a few instances where student questions and responses were completely ignored by the student teacher due to lack of time to finish the lesson or difficulty in maintaining classroom control.

One limitation of this study was the small sample size employed in data collection and classroom observations. At the beginning of student teaching, 52 student teachers had agreed to participate in the study. Unfortunately, after the first week, only 20 student teachers still agreed to participate. As found by Strawhecker (2005) “large-scale studies on pedagogical content knowledge have not been conducted” (p. 2). Ball (1990) and Ma (1999) have contributed a more complete understanding of how pre-service mathematics teachers’ content knowledge has developed and Wilson et al. (2001) suggested ways of reorganizing pedagogy and content within mathematics methods courses using a constructivist approach. According to Strawhecker (2005), there is currently no model that integrates both mathematical content and pedagogy in the context of teaching for student teachers. However, one aim of this study was to contribute to current findings and understandings between content for teaching mathematics combined with general and content specific pedagogical skills among elementary and middle level student teachers.

Much work was put into the COPAT-R to improve the original COPAT. Even though the COPAT-R was redesigned to eliminate subjectivity and rater bias, additional work needs to be accomplished to align descriptors with overall domain scores. In this study, the overall domain scores were not used in comparing pedagogical competencies and development because of this misalignment between descriptor totals and their subsequent domain score. The researcher chose to focus solely on descriptors within each domain. A numeric scale that aligns and categorizes descriptor totals into domain levels, such as commendable, acceptable, and inadequate, needs to be designed.

There is a high learning curve that student teachers experience in both teaching mathematics content and implementing effective pedagogical skills within mathematics classrooms. General and content specific pedagogical behaviors must be developed in conjunction with having deep, vast, and thorough understanding of mathematical content knowledge. In addition, more large-scale studies need to be conducted in the classrooms of both elementary and middle level student teachers in order to understand what is actually occurring in the classrooms. Additionally, differences between certification levels should be examined. This will help teacher preparation programs better prepare pre-service teachers and understand the inter-relatedness of pedagogical and content knowledge for teaching mathematics skills and factors that influence mathematics teaching and learning. Educators and researchers understand that both pedagogy and mathematical content knowledge are important and inter-related but are still trying to determine how they are related and to what degree are they are dependent on each other, especially for novice teachers of elementary and middle levels. This study made an initial attempt to contribute to this knowledge base of amalgamating mathematical knowledge for teaching and pedagogy.

CHAPTER V

SUMMARY AND CONCLUSIONS

The synthesis of results from all three articles encompassed a more complete portrait of pre-service teachers' mathematical teaching development; not just through a bifurcated fractionalized lens. Typically, in empirical studies, multi-faceted areas influencing pre-service teacher development in mathematics are examined in few or very specific areas of either PCK or CKTM and do not always include observing pre-service teachers in the classroom. By observing pre-service teachers actually teaching mathematics, interviewing them about their self-perceptions of PCK and mentoring support and assessing their CKTM over multiple time points throughout their initial full-time teaching experience, the researcher hoped to gain a more complete and comprehensive understanding of what factors and differences influenced elementary and middle level pre-service teachers' ability to teach mathematics. Despite having a small sample size, this study employed use of multiple groups, measures, and research designs, to gain the most complete and all-inclusive understanding of how these three factors influenced pre-service teachers' mathematical teaching development.

Development of Researcher

The extensive process of observing, assessing, and interviewing student teachers and interns concerning their PCK, CKTM, and mentoring support development has enabled the researcher to become an authority in understanding differences and relationships between elementary and middle level pre-service teachers. Understanding the complex nature of PCK and CKTM development requires a solid understanding of the instruments used to assess PCK and CKTM. Before beginning this study, the researcher was cognizant of the extensive knowledge required to administer, analyze, and report results gathered from the two primary instruments used in this study, the CKTM and COPAT. Therefore, extensive training to use both instruments was obtained, a pilot study was conducted, and continued support and guidance from the creators of both instruments was employed. The researcher also relied upon her fifteen years of elementary, middle, and university-teaching experiences to report results and draw inferences and conclusions. As a result of having extensive preparation and training, teacher knowledge and background experience, using multiple instruments over several time points, and employing multiple groups, the researcher felt confident in assessing pre-service teachers' PCK and CKTM development.

Instrumentation Improvements

Initially, the focus for using the COPAT was as an observational instrument to compare domain scores of ELS and MLS teachers. However, through continued use, trials, and analysis, the researcher became aware of issues related to the validity and reliability of the data collected from the COPAT. By adjusting the value of each descriptor as contributing to domain scores, the descriptors and domains were better aligned to match the theoretical construct embodied within each domain. Use of an extant instrument, such as the original COPAT, provided the researcher the opportunity to improve the pedagogical content knowledge indicators of the instrument, thus collecting more accurate participant data. However, a numeric scale that aligns and categorizes descriptor totals into domain levels, such as commendable, acceptable, and inadequate, needs to be further developed.

Contribution of Study

This study provided a comprehensive examination of PCK and CKTM development for mathematics education pre-service ELS and MLS teachers, thus contributing to the scholarly work of researchers in the field of mathematics education and pre-service teacher development. Wilson, Floden, and Ferrini-Mundy (2002) reported that the Department of Education (2002) has asked for rigorous empirical research in five key areas of teacher preparation. This current study advanced the research in three of the five areas: (1) “what kinds of subject matter preparation, and how much of it do pre-service teachers need? Are there differences by grade level or subject area; (2) what kinds of pedagogical preparation, and how much of it, do prospective teachers need? Are there differences by grade level of subject area; and (3) what kinds of timing, and amount of clinical training (student teaching) best equip pre-service teachers for classroom practice?” (p. 191).

First, this study has contributed to the understanding that mathematics knowledge, alone, is not enough to effectively teach mathematics. Ball (2001) has contended that educators need both the ‘common’ and ‘specialized’ knowledge to teach mathematics. Recently, Ball has begun to investigate the inter-relatedness of pedagogical content knowledge with mathematical knowledge for teaching in hopes of closing the gap between the two (Ball & Bass, 2000). This study contributed to their research by focusing on pre-service teachers, not just in-service teachers, in order to better understand "what teachers need to know and helping them learn to use it" (p. 101). Understanding PCK and CKTM factors, issues, and the interplay between them in preparing pre-service teachers before they enter the classroom will help alleviate mathematics teaching difficulties, misconceptions, and inadequate content understanding (Ball & Bass, 2000; Capraro et al., 2005; Strawhecker, 2005).

Second, this study has contributed to the understanding of how pedagogical content knowledge develops through the process of actual teaching. Sherin's (2002) study examined the development of teachers' content knowledge during mathematics instruction. Sherin claimed that, "pedagogical reasoning acts on subject matter knowledge to produce pedagogical content knowledge" (p. 146). It is through teaching mathematics content to students that teachers begin to develop or transform this knowledge to PCK. She contends that the cycle of negotiations between teacher and student can result in the teachers' increased subject matter knowledge and PCK. Finally, she states, "researchers should investigate ways to promote [mathematical] learning that occurs during instruction" (p. 147). Rather than studying in-service teachers, as in Sherin's study, this current study investigated factors and relationships that developed between pre-service teachers' CKTM and PCK. By examining the inter-relatedness of CKTM and PCK through observations of mathematics lessons, interactions and discussions with pre-service teachers and reliable assessments, this study adds to Sherin's research in that teaching becomes learning through a cycle of negotiations with students, and the integration between subject matter knowledge and PCK, in which the development of new knowledge complexes occurs.

Third, this study helped to delineate and understand differences between ELS and MLS pre-service teachers. Even though there are important issues and differences to examine within certification level (An, Kulm, & Wu, 2004; Blanton, Berenson & Norwood, 2001; Foss & Kleinsasser, 1996; McGowen & Davis, 2002), there is also a need for university mathematics educators to understand inherent differences within ELS and MLS classrooms and specific CKTM and PCK teaching practices that pre-service teachers will encounter and be expected to implement (Wilson, Floden, & Ferrini-Mundy, 2002). Mathematics educators responsible for training pre-service teachers should be knowledgeable of PCK and CKTM factors in order to instruct and guide ELS and MLS pre-service teachers in best practices. This study provided some of those needs and practices inherent to ELS and MLS mathematics classroom experiences.

Understanding mentoring support for pre-service mathematics teachers is another area that needs significant research and understanding (Wang & O'Dell, 2002). Hudson and Peard (2005) reported that the ultimate aim of mathematics mentors is to support the development of beginning teachers in best practices. The current study adds to this research by examining urban interns' perceptions of their mentor's roles and what best practices helped or hindered their ability to teach mathematics. This study allowed first year interns to discuss how their mentoring support enabled or hindered their ability to teach mathematics, specifically outlining skills, factors, and behaviors that allowed them to teach using best mathematical practices.

Another important contribution is the improved understanding of CKTM development for pre-service teachers. The CKTM survey (2004) created by researchers at the University of Michigan through the Learning Mathematics for Teaching (LMT) project, has primarily been distributed and assessed with in-service teachers. Limited use of this instrument on pre-service teachers has been conducted and findings published. In addition, this current study not only assessed CKTM development between ELS and MLS teachers, it also compared the relationship between CKTM and PCK development for both groups. This research extends Ball's (2001) work to pre-service teachers by examining current practice in the preparation of teachers that includes an added dimension of triangulating the results of CKTM using a classroom observation instrument that allowed an understanding of pre-service teachers' actual pedagogical teaching practices.

Since the COPAT was based on the INTASC Standards (1992), which provided the teaching standards framework for new teachers, this study helped to show how ELS and MLS teachers used developing mathematics and general pedagogical standards in the classroom. The INTASC Standards outlined both general and content-specific pedagogical skills and behaviors. This study examined each of these pedagogical behaviors within actual classroom experiences and through interviewing pre-service teachers on factors that influenced that development, such as mentor support. A triangulation of in-class observations, self-report assessments and interviews were used to obtain a comprehensive understanding of pedagogical content knowledge development between ELS and MLS teachers.

Recommendations to Further Research

To date, the CKTM instrument (Hill & Ball, 2004) is the most widely used and comprehensive assessment of content knowledge for teaching mathematics. However, this instrument is designed to assess answers as “right or wrong” only and does not allow for explanation for selected answers. A similar, but open-ended instrument that assesses CKTM is needed to further understand and explain pre-service teachers CKTM development. The researcher attempted to use a PCK instrument to supplement the findings of the CKTM instrument to obtain an accurate and comprehensive understanding of pre-service teachers’ “specialized” content knowledge for teaching mathematics. However, it would be more beneficial if mathematics educators explained their own CKTM reasoning and logic. Assessing the inter-relatedness and influences of PCK and CKTM development for pre-service teachers makes this a multifaceted topic for contemporary mathematics educators and researchers.

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APPENDIX A

Study of Instructional Improvement/Learning Mathematics for Teaching
Content Knowledge for Teaching Mathematics Measures (CKT-M measures)
Released Items, 2005[3]

ELEMENTARY CONTENT KNOWLEDGE ITEMS

1. Ms. Dominguez was working with a new textbook and she noticed that it gave more attention to the number 0 than her old book. She came across a page that asked students to determine if a few statements about 0 were true or false. Intrigued, she showed them to her sister who is also a teacher, and asked her what she thought.

Which statement(s) should the sisters select as being true? (Mark YES, NO, or I'M NOT SURE for each item below.

		Yes	No	I'm not sure
a)	0 is an even number.	1	2	3
b)	0 is not really a number. It is a placeholder in writing big numbers.	1	2	3
c)	The number 8 can be written as 008.	1	2	3

2. Imagine that you are working with your class on multiplying large numbers. Among your students' papers, you notice that some have displayed their work in the following ways:

Student A	Student B	Student C
3 5	3 5	32 5
x 2 5	x 2 5	x 5
1 2 5	1 7 5	2 5
+ 7 5	+ 7 0 0	1 5 0
8 7 5	8 7 5	1 00 0
		+ 6 0
		8 7 5

Which of these students would you judge to be using a method that could be used to multiply any two whole numbers?

		Method would work for all whole numbers	Method would NOT work for all whole numbers	I'm not sure
a)	Method A	1	2	3
b)	Method B	1	2	3
c)	Method C	1	2	3

3. Ms. Harris was working with her class on divisibility rules. She told her class that a number is divisible by 4 if and only if the last two digits of the number are divisible by 4. One of her students asked her why the rule for 4 worked. She asked the other students if they could come up with a reason, and several possible reasons were proposed. Which of the following statements comes closest to explaining the reason for the divisibility rule for 4? (Mark ONE answer.)

a) Four is an even number, and odd numbers are not divisible by even numbers.

b) The number 100 is divisible by 4 (and also 1000, 10,000, etc.).

c) Every other even number is divisible by 4, for example, 24 and 28 but not 26.

d) It only works when the sum of the last two digits is an even number.

4. Ms. Chambreaux's students are working on the following problem:

Is 371 a prime number?

As she walks around the room looking at their papers, she sees many different ways to solve this problem. Which solution method is correct? (Mark ONE answer.)

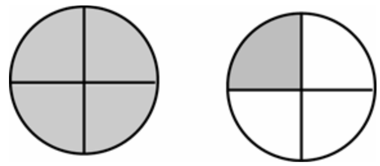
a) Check to see whether 371 is divisible by 2, 3, 4, 5, 6, 7, 8, or 9.

b) Break 371 into 3 and 71; they are both prime, so 371 must also be prime.

c) Check to see whether 371 is divisible by any prime number less than 20.

d) Break 371 into 37 and 1; they are both prime, so 371 must also be prime.

5. Mrs. Johnson thinks it is important to vary the whole when she teaches fractions. For example, she might use five dollars to be the whole, or ten students, or a single rectangle. On one particular day, she uses as the whole a picture of two pizzas. What fraction of the two pizzas is she illustrating below? (Mark ONE answer.)



a) 5/4

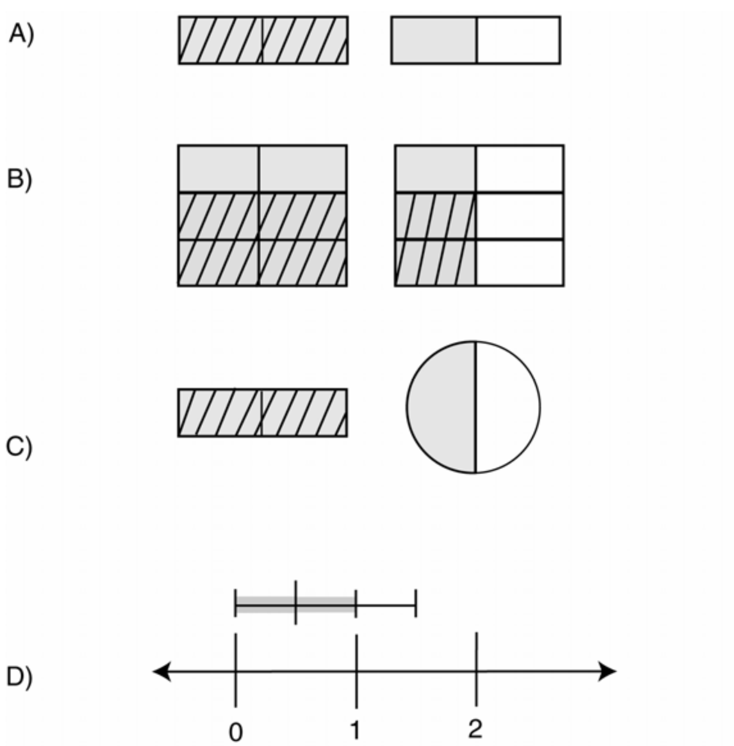
b) 5/3

c) 5/8

d) 1/4

6. At a professional development workshop, teachers were learning about different ways to represent multiplication of fractions problems. The leader also helped them to become aware of examples that do not represent multiplication of fractions appropriately.

Which model below cannot be used to show that $1\frac{1}{2} \times \frac{2}{3} = 1$? (Mark ONE answer.)



7. Which of the following story problems could be used to illustrate

$1\frac{1}{4}$ divided by $\frac{1}{2}$? (Mark YES, NO, or I'M NOT SURE for each possibility.)

	Yes	No	I'm not sure
a) You want to split $1\frac{1}{4}$ pies evenly between two families. How much should each family get?	1	2	3
b) You have $1.25 and may soon double your money. How much money would you end up with?	1	2	3
c) You are making some homemade taffy and the recipe calls for $1\frac{1}{4}$ cups of butter. How many sticks of butter (each stick = $\frac{1}{2}$ cup) will you need?	1	2	3

8. As Mr. Callahan was reviewing his students' work from the day's lesson on multiplication, he noticed that Todd had invented an algorithm that was different from the one taught in class. Todd's work looked like this:

$$\begin{array}{r} 983 \\ \underline{\times\ 6} \\ 488 \\ +\underline{5410} \\ 5898 \end{array}$$

What is Todd doing here? (Mark ONE answer.)

a) Todd is regrouping ("carrying") tens and ones, but his work does not record the regrouping.

b) Todd is using the traditional multiplication algorithm but working from left to right.

c) Todd has developed a method for keeping track of place value in the answer that is different from
d) the conventional algorithm.

e) Todd is not doing anything systematic. He just got lucky – what he has done here will not work
f) in most cases.

MIDDLE SCHOOL CONTENT KNOWLEDGE ITEMS

9. Students sometimes remember only part of a rule. They might say, for instance, “two negatives make a positive.” For each operation listed, decide whether the statement “two negatives make a positive” sometimes works, always works, or never works. (Mark SOMETIMES, ALWAYS, NEVER, or I’M NOT SURE)

	Sometimes works	Always works	Never works	I’m not sure
a) Addition	1	2	3	4
b) Subtraction	1	2	3	4
c) Multiplication	1	2	3	4
d) Division	1	2	3	4

10. Mrs. Smith is looking through her textbook for problems and solution methods that draw on the distributive property as their primary justification. Which of these familiar situations could she use to demonstrate the distributive property of multiplication over addition [i.e., a (b + c) = ab + ac]?
(Mark APPLIES, DOES NOT APPLY, or I’M NOT SURE for each.)

	Applies	Does not apply	I’m not sure
a) Adding $\frac{3}{4} + \frac{5}{4}$	1	2	3
b) Solving 2x – 5 = 8 for x	1	2	3
c) Combining like terms in the expression $3x^2 + 4y + 2x^2 - 6y$	1	2	3
d) Adding 34 + 25 using this method: $\begin{array}{r} 34 \\ +25 \\ \hline 59 \end{array}$	1	2	3

11. Students in Mr. Carson’s class were learning to verify the equivalence of expressions. He asked his class to explain why the expressions a – (b + c) and a – b – c are equivalent. Some of the answers given by students are listed below.

Which of the following statements comes <u>closest</u> to explaining why a – (b + c) and a – b – c are equivalent? (Mark ONE answer.)

a) They’re the same because we know that a – (b + c) doesn’t equal a – b + c, so it must equal a – b – c.

b) They’re equivalent because if you substitute in numbers, like a=10, b=2, and c=5, then you get 3 for
c) both expressions.

d) They’re equal because of the associative property. We know that a – (b + c) equals (a – b) – c which
e) equals a – b – c.

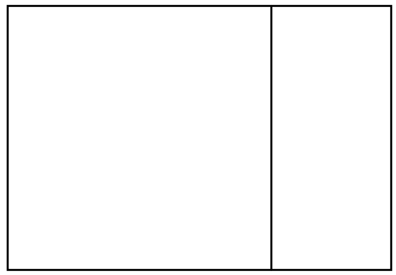
f) They’re equivalent because what you do to one side you must always do to the other.

g) They’re the same because of the distributive property. Multiplying (b + c) by –1 produces –b – c.

12. Ms. Whitley was surprised when her students wrote many different expressions to represent the area of the

figure below. She wanted to make sure that she did not mark as incorrect any that were actually right. For each of the following expressions, decide whether the expression <u>correctly represents</u> or <u>does not correctly represent</u> the area of the figure.

(Mark REPRESENTS, DOES NOT REPRESENT, or I'M NOT SURE for each.)



		Correctly represents	Does not correctly represent	I'm not sure
a)	$a^2 + 5$	1	2	3
b)	$(a + 5)^2$	1	2	3
c)	$a^2 + 5a$	1	2	3
d)	$(a + 5)a$	1	2	3
e)	$2a + 5$	1	2	3
f)	$4a + 10$	1	2	3

13. Ms. Hurlburt was teaching a lesson on solving problems with an inequality in them. She assigned the following problem.

$$-x < 9$$

Marcie solved this problem by reversing the inequality sign when dividing by – 1, so that $x > -9$. Another student asked why one reverses the inequality when dividing by a negative number; Ms. Hurlburt asked the other students to explain. Which student gave the <u>best explanation</u> of why this method works? (Mark ONE answer.)

a) Because the opposite of x is less than 9.

b) Because to solve this, you add a positive x to both sides of the inequality.

c) Because $-x < 9$ cannot be graphed on a number line, we divide by the negative sign and reverse the inequality.

d) Because this method is a shortcut for moving both the x and 9 across the inequality. This gives the same answer as Marcie's, but in different form: $-9 < x$.

APPENDIX B

INTERN INTERVIEW QUESTION

1. How has your campus mentor helped you develop your ability to teach mathematics?

2. How have the other math teachers in your school helped you develop your ability to teach mathematics?

3. Were there any other school colleagues, not on your team or in your grade level that helped you to develop your ability to teach mathematics?

4. How did your district supervisor help you develop your ability to teach mathematics?

5. How did your principal help you develop your ability to teach mathematics?

6. How did any other building administrators help you develop your ability to teach mathematics?

7. How did other district administrators help you develop your ability to teach mathematics?

8. Describe what specific teaching skills, factors, behaviors, you perceived were instrumental in your ability to teach mathematics.

9. Were there any specific teaching factors, or behaviors that you perceived hindered your ability to teach mathematics?

10. Do you have a teaching job for next year?

APPENDIX C

COPAT-R

Domains	Pedagogy and Content-Specific Descriptors
IP	System for materials distribution Lesson plan ready Selects instructional goals
IEM	Routines are identified/evident Inappropriate behavior handled effectively Consistent application of rules Minimal disruptions to class Students on task quickly High levels of time on task Students engaged productively Prevention techniques used Materials ready Necessary items available Sets reasonable work standards Assigns independent practice
IL	Objective, purpose and intent clearly presented Lesson initiation; interesting, compelling Speech, fluent, clear Directions clear and precise Transitions, smooth Interactive All parts of lesson tie together Lively/appropriate pace Student reflection include Engagement, equitable Closure included All critical lesson components evident Lesson modifications made, if needed Lesson culturally responsive Objective met Student seating supports lesson Strategies, varied Examples relevant

Appendix C Continued

Domain	Pedagogy and Content-Specific Descriptors
IC	Prior knowledge point of reflection Strategies, developmental (age appropriate) Strategies, adjusted as needed Questions (open, varied levels) Lesson has core integration Critical thinking encouraged Content information accurate Student centered
IM	Monitoring occurs Circulates to check performance Checks progress frequently Checks both whole class and individual Stands/sits to see all students Frequent visual scanning Immediate feedback on work or answers Affirms correct answers Uses informal or formal assessments
IMF	Effective motivation techniques used Sustains feedback with incorrect answers Appears enthusiastic Respectful and valued responses Positive climate in classroom Students appear motivated Responsive to student questions Receives oral/written data Provides guided practice

Note: IP = Instructional preparedness, IEM = Instructional motivation and feedback, IL = Instructional lesson, IC = Instructional content, IM = Instructional monitoring, IMF = Instructional motivation and feedback.
*Note: All questions were asked within the context of a mathematics lesson.

APPENDIX D

STUDENT TEACHER INTERVIEW QUESTIONS

Domain I: Instructional preparedness
1. What specific teaching skills in your *instructional preparedness* do you believe are most competent?
2. What specific teaching skills in *instructional preparedness* do you believe could be improved or need continued development?

Domain II: Instructional environment/management
3. What specific teaching skills in your *instructional environment/management* do you believe are most competent?
4. What specific teaching skills in *instructional environment/management* do you believe could be improved or need continued development?

Domain III: Instructional lesson
5. What specific teaching skills in your *execution of instructional lesson* do you believe are most competent?
6. What specific teaching skills in *execution of instructional lesson* do you believe could be improved or need continued development?

Domain IV: Instructional monitoring
7. What specific teaching skills in *instructional monitoring* do you believe are most competent?
8. What specific teaching skills in *instructional monitoring* do you believe could be improved or need continued development?

Domain V: Instructional motivation and feedback
9. What specific teaching skills in your *instructional motivation and feedback* do you believe are most competent?
10. What specific teaching skills in *instructional motivation and feedback* do you believe could be improved or need continued development?

VITA

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EDUCATION

TEXAS A&M UNIVERSITY College Station, Texas Curriculum & Instruction Mathematics Education	Ph. D., Ed., 2008
Texas A&M University College Station, Texas Educational Psychology, Specializing in the Gifted & Talented	M.S., Ed., 1993
Texas A&M University College Station, Texas Curriculum & Instruction Mathematics Specialization (K-8th)	B.S., Ed., 1989

PROFESSIONAL EXPERIENCE

September 2007-May 2008	Texas A&M University; College Station, Texas Instructor for a Mathematics Methods in early Childhood Education course –ECFB 440
August 2004-Dec. 2005	Texas A&M University; College Station, Texas Instructor for an Integrated Mathematics and Science course -MASC 450
August 2004-Sept. 2006	Texas A&M University; College Station, Texas Video analyst for the Middle School Mathematics Project.